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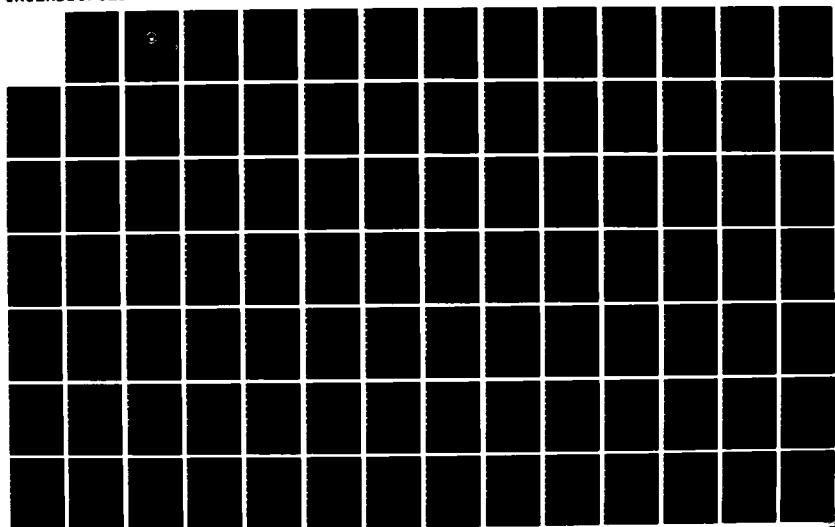
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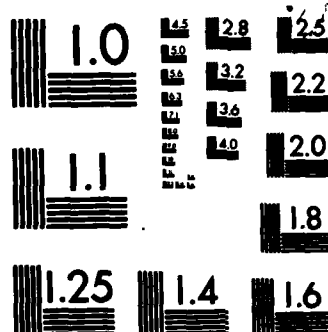
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THESIS

THE INTRODUCTION OF UNCERTAINTY TECHNIQUES
TO THE PRODUCTIVITY INVESTMENT FUND

by

Edward A. Lenio

March 1984

Thesis Advisor:

D. C. Boger

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**The Introduction of Uncertainty Techniques
to the Productivity Investment Fund**

by

Edward A. Lenio
Lieutenant Commander, United States Navy
B.A., The Citadel, 1974

Submitted in partial fulfillment of the
requirements for the degree of

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March 1984**

Author:

Edward A. Lenio

Approved by:

Don C. Bogen

Thesis Advisor

Glenn F. Lindberg

Second Reader

Harold R. Washburn

Chairman, Department of Operations Research

Kenneth T. Manly

Dean of Information and Policy Sciences

ABSTRACT

Each year the Defense Productivity Program Office (DPPO) disburses funds for Productivity Investment Projects (PIFs). The purpose of these projects is to increase productivity within the Department of Defense (DoD). To enhance these efforts, DPPO requested a study to be conducted to determine if methods of risk or uncertainty will affect the results obtained by the current procedure. This study applies various principles of uncertainty to this procedure and examines their impact on the project rankings. A background of DPPO and PIFs is presented together with discussion of risk and uncertainty techniques, as well as the economic indicators used in ranking projects. A model is then explained which will introduce uncertainty into the present procedure. Results of the initial comparison and sensitivity analysis is revealed. Conclusions are drawn based on these results and recommendations concerning alternate procedures and possible further research are presented.

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I. INTRODUCTION

A. BACKGROUND

As early as February 1969, the Department of Defense (DoD) began to place emphasis upon increasing efficiency and productivity within its department. This was also complementary to the overall efforts of the federal government. These efforts led to the creation of the Defense Productivity Program (DPP) whose primary objective is "to achieve optimum productivity growth (increase the amount of goods produced or services rendered in relation to the amount of resources expended) throughout DoD" [6: pg. 1]. It should be noted that this does not include contractors. It is intended solely for DoD and the Service Components. Furthermore, this approach called for the development of Productivity Enhancing Capital Investments (PECIs). Responsibility for the administration of the program was assigned to the Assistant Secretary of Defense; Manpower, Reserve Affairs and Logistics (ASD(MRA&L)) who designated his authority to the Defense Productivity Program Office (DPPO). This Office acts as the coordinator for the DPP and serves as liaison between the Office of the Secretary of Defense (OSD) and Service Components in productivity matters.

One of the problems faced by DPPO in the management of PECIs was the process of allocating funds. Due to budget

constraints, not all of the recommended productivity projects could receive funds. To alleviate this dilemma, projects are ranked according to three economic indicators: internal rate of return (IRR); return on investment (ROI); and investment per manpower space saved (INVPERSV). Projects then receive funding according to their rank until the budget for that fiscal year is exhausted.

B. STATEMENT OF THE PROBLEM

DPPO's concern is to ensure that funds are allotted to the most productive projects. Considering that projects forecast uncertain savings and costs into the future, this is an understandable concern. Under the present procedure, DPPO can only validate the use of correct discount rates in making these predictions. However, the realization of these forecasted costs and savings is questionable. The introduction of methods involving risk and uncertainty may aid in the efficient allocation of funds. The question to be addressed in this thesis is whether or not the use of risk and uncertainty techniques will significantly change the current ranking of projects.

C. OBJECTIVES OF THE ANALYSIS

The objectives of this analysis will be to develop a model incorporating uncertainty, rank the projects using the model, and compare these results to the current ranked list. Since the present method ranks projects according to IRR,

ROI, and INVPERSV, the model will apply risk factors to these areas. The model will not introduce any new variables (e.g., net present value, payback period, etc.) which might affect the rankings. Furthermore, only those equations used by DPPO to calculate economic indicators will be presented in the model unless a simpler formula exists that portrays identical behavior. This specifically refers to the method used to compute IRR. The current method uses average yearly savings and the model utilizes constant yearly savings. Although the formulas will result in different IRRs, any change in savings will result in an equi-proportional change in rate of return.

Additionally, sensitivity analysis will be performed on the model. Initial analysis will restrict itself to the single variable case and will be expanded later to consider multivariable deviations. The purpose of this analysis will be to determine the level of change of input variables to effect a change in ranking.

D. CONTENTS

The following chapter introduces the reader to DPPO and the Productivity Investment Fund (PIF). The background of DPPO and its functions, an overview of PECI's, the PIF's past funding levels, and procedures used to obtain these funds will be addressed. Chapter III will familiarize the reader with risk and uncertainty as well as techniques in dealing with each. It will further apply the use of

uncertainty to the PIF. Chapter IV defines the terms and gives a detailed description of the model. It will explain how branch values were obtained and discuss the basic assumptions of the model. In Chapter V, the ranking derived using uncertainty will be compared to the current ranking, sensitivity analysis performed, and the results of the analysis revealed. Chapter VI will summarize this thesis and present conclusions and recommendations derived therefrom.

II. DEFENSE PRODUCTIVITY PROGRAM OFFICE (DPPO)

A. BACKGROUND

As previously stated, emphasis on productivity and efficiency within the Department of Defense (DoD) began in 1969. Initial attempts called for the establishment of the Defense Economic Analysis Council in October 1972. This council served in an advisory capacity to the Assistant Secretary of Defense (Comptroller) and encouraged the application of economic analysis and program evaluation in order to increase the cost effectiveness of budget proposal inputs to the Planning, Programming and Budgeting System (PPBS). In August 1975, DoD Directive 5010.31 established the Defense Productivity Program. The primary objective of the program is "to achieve optimum productivity growth (increase the amount of goods produced or services rendered in relation to the amount of resources expended) throughout DoD" [6: pg. 1]. This directive required Defense organizations to be both effective and efficient in the utilization of all types of fund resources (operating and investment) as well as labor resources. Furthermore, the directive identified productivity measurement, productivity enhancement, and productivity evaluation as key elements to the program. Although all three elements play important roles in the program's success, only Productivity Enhancement (PE) will be discussed in this paper.

In 1979 DoD Directive 5010.31 was reissued, forming the Defense Productivity Program Office (DPPO) which had over-all responsibility of the Defense Productivity Program (DDP). DPPO was placed under the cognizance of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) (ASD, MR&L) in 1981.

The DPP to be developed would include a planned approach to PE including, but not limited to, the development of Productivity Enhancing Capital Investment (PECI) programs. PECIs are classified as:

1. Office of the Secretary of Defense (OSD) sponsored projects;
2. Industrial Fund Fast Payback (IFFP) projects; and
3. Other Component Sponsored Investment (CSI) projects.

OSD sponsored projects include the following categories:

- a. Productivity Enhancing Incentive Fund (PEIF) projects.

These projects are

...fast payback PECI projects financed from drawing accounts established within annual appropriations. These projects cannot exceed \$100,000 or cost limitations established by OSD (whichever is greater) and must amortize within 2 years of the date they become operational. [7: pg. 4]

- b. Productivity Investment Fund (PIF) projects.

These are projects that have been

...competitively selected by OSD from candidate proposals submitted by DoD Components and financed through traditional budget appropriation processes from funds set aside by OSD for this purpose. PIF projects must be expected to amortize within 4 years of the date they become operational. [7: pg. 4]

Since this thesis will deal only with PIF projects, discussion on PEIF, IFFP and CSI projects will be omitted. However, PIF funding levels and procedures will be of interest later and will be the next topic.

B. PRODUCTIVITY INVESTMENT FUND (PIF) FUNDING LEVELS

To better understand the magnitude of these investments, a look at past and proposed funding levels may prove beneficial. The first PIFs were funded in 1981. Money for the program was \$105 million that year and \$110 million for 1982. David Whipple and Jack LaPatra [15] completed an evaluation of DPPO's activities revealing,

The average cost of PIFs has been \$2 million, with an average payback of 2.5 years. Having an average lifetime investment of \$11.2 million, they are expected to return \$6 for \$1 invested. Approximately \$700 million has been requested under PIF by all services for FY 83-87. [15: pg. V-15]

The average cost of proposed projects for FY84 budgeting is approximately \$1.6 million, slightly less than previous years. How a Service Component proceeds to obtain funding for a productivity project is the next topic.

C. PIF FUNDING PROCEDURE

Department of Defense Instruction (DoDI) 5010.36 establishes policy and prescribes procedures for the Productivity Enhancing Capital Investment (PECI) program with which the PIF is affiliated. Excerpts from this directive concerning policy indicate the intent of the program by stating, "PECI funding procedures focus upon financing those projects that

substitute capital for labor" [7: pg. 2]. In yet another section, guidelines for project selection is delineated,

Top priority will be given to those potential investments that amortize in the shortest period of time and those with the highest potential internal rate of return on investment or the highest net present value. [7: pg. 2]

Furthermore, the instruction dictates a specific format for DoD Components to follow when requesting money for productivity projects. A copy of the format is contained in Reference 7. Some of the required information that will be of particular interest later includes total cost, total savings, internal rate of return (IRR), savings to investment ratio, rate of investment per manpower space and cost-benefit streams. These concepts are explicitly defined and evaluated in Chapter IV below. From this base, net present value (NPV) and payback period (P-P) can be calculated and economic analysis performed. For purposes of uniformity, the term savings to investment ratio is synonymous with return on investment (ROI).

The sequence of events from project initiation to project funding may be outlined as follows:

1. A DoD Component prepares an initial proposal for a project categorized as a PIF using the format of DoDI 5010.36.
2. This proposal is forwarded via the appropriate chain of command for approval.
3. Each service then compiles a list of the "best" projects, normally in rank order, that meets its needs and objectives.

4. These lists are then forwarded to DPPO who conducts an economic screen. The screening process consists of recomputing the information and checking the accuracy of each proposal in terms of calculations and validity of projections.

5. The projects are separated according to function, i.e., Automatic Data Processing (ADP), aircraft maintenance, etc., and forwarded to the appropriate Office of the Secretary of Defense (OSD) Functional Manager for a final screening.

6. Projects are returned to DPPO who computes a final ranking of all approved projects. This ranking is based on three key indicators: IRR, ROI and Investment Per Manpower Space Saved (INVPERSV). Each indicator receives equal weight with ties in rank going to the project with the highest IRR.

7. From the current budget set aside for PIF projects, all out-year funding on prior approved projects is deducted, i.e., a FY81 project requiring funds for two years receives its FY82 money from the FY82 budget. A running cumulative sum of investment costs on currently approved projects is performed and the balance of PIF monies allotted. It should be noted that not all projects approved will be funded.

8. DPPO then issues a Program Budget Decision (PBD) to the services who, in turn, add this money to their respective Service Budget requests.

9. Once Congressional approval is received, as it usually is, the funds are appropriated accordingly. This entire

cycle takes approximately 1 year to complete and any project not funded that year may reapply the following year.

At this point, the reader should have a basic understanding of DPPO, PIF and the procedures used to obtain project funding. What may not be so clear is the role that risk and uncertainty play. The next chapter attempts to introduce these terms and relate them to the PIF.

III. RISK AND UNCERTAINTY

A. INTRODUCTION

The word decision may be defined as a choice among alternatives. In any investment, a decision may be made under conditions of certainty, risk, or uncertainty. Certainty postulates that the decision maker knows in advance all parameter values that will affect the decision. With risk, he is aware of all future states that will affect his decision and can place a probability distribution on the value of the occurrence of each state, i.e., the probability distribution which describes possible outcomes is known. According to Morris [13], uncertainty implies that a decision maker may or may not be aware of all possible states and may or may not be able to place a probability distribution on the occurrence of each.

Figure 1 depicts a decision problem represented by a payoff matrix. Here, the columns, s_1, s_2, \dots, s_n , represent future states of nature and the rows a_1, a_2, \dots, a_m are the alternatives. The P_{ij} 's, where $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$, represent the payoff of alternative i in state j . If a probability distribution can be placed on the states of nature, then Morris [12], Fishburn [8], Luce [10] and Savage [14], give several principles that may be used to aid in decision making. These principles, expectation, most probable

	s_1	s_2	\dots	s_n
a_1	P_{11}	P_{12}	\dots	P_{1n}
a_2	P_{21}	P_{22}	\dots	P_{2n}
\vdots	\vdots	\vdots		\vdots
a_m	P_{m1}	P_{m2}	\dots	P_{mn}

Figure 1. Typical Payoff Matrix

future, expectation-variance, and aspiration level, will be discussed in detail in Chapter IV. If the decision is made under uncertainty, then the Laplace Principle, minimax or maximin, minimin or maximax, Savage's minimax regret, and the Hurwicz principle are common principles of choice.

Clark, et al [4] explain another technique in dealing with risk and uncertainty known as Utility Theory. This is an attempt to formalize rational decision making. In this approach, preferences among alternatives are specified by the decision maker. The utility value attached to the various alternatives then represent all aspects that are relevant to the decision.

If a decision maker perceives different levels of risk associated with the future states, then the Certainty Equivalent Method may prove useful. This approach permits adjustment for risk by incorporating the decision maker's utility preference for risk. In an economic scenario, it is reasonable to assume that estimates of cash flows are

likely to be more accurate during the early periods of an investment than in the later years. Subsequently, the risk should be adjusted to reflect this. In dealing with similar situations, whether economic or not, the certainty equivalent method may be preferred.

Raiffa [13] explains a popular decision technique known as a decision flow diagram or "tree." Here, a manager has several courses of action he may take. For each course of action, there may be several consequences associated with it. Furthermore, with each consequence there exists a probability of that event occurring. Figure 2 depicts a simple example of a decision tree. In this example, a decision maker has a choice of investing \$15,000 on a project.

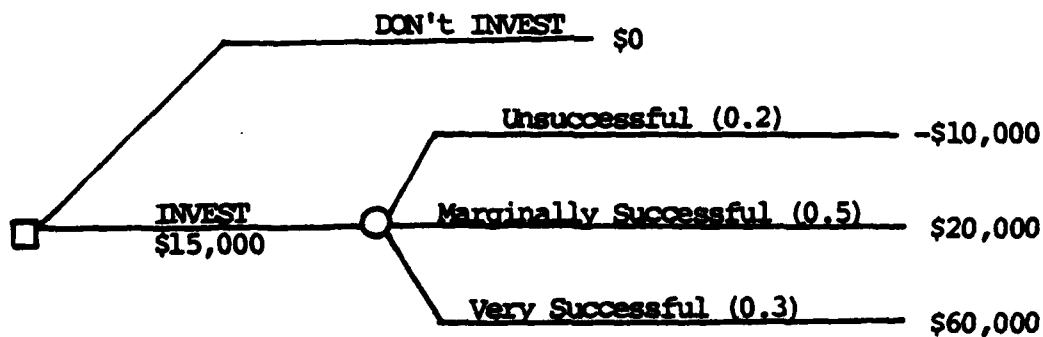


Figure 2. A Simple Decision Tree

If he decides not to invest, he gains or loses nothing. If he invests, then the project will be unsuccessful with probability 0.2, marginally successful with probability of 0.5 or highly successful with probability 0.3. In this

particular case the decision maker faces an 80 percent chance of a successful project. Taking this one step further, the principle of expectation or expected value can be used. Mathematically, expected value, \bar{R} is

$$\bar{R} = \sum_{i=1}^N R_i P_i \quad (1)$$

where:

\bar{R} is expected value,

R_i is the value of the i th outcome,

P_i is the probability the i th outcome occurs,

N is the total number of outcomes.

Applying this to the decision tree yields

$$\begin{aligned} \bar{R} &= (-\$10,000 \times 0.2) + (\$20,000 \times 0.5) + (\$60,000 \times 0.3) \\ &= \$26,000. \end{aligned}$$

Depending upon the decision maker's risk posture, i.e., the minimum return he will accept on this investment, he may or may not invest.

It should be noted that the probabilities associated with the occurrence of consequences may not be very easy to obtain. When reviewing the available courses of action, the decision maker always has the option of delaying a decision until further data can be gathered which might provide insight

into the results of the various choices. However, delaying a decision usually has an associated cost. This cost may be in terms of time, money, workforce or numerous other things. According to Mooney [11], significant in this area are the benefits derived from increased information and the increase in certainty as a function of time. Figures 3 and 4 graphically illustrate this problem.

The dilemma of determining how much information is cost effective can often be viewed as a problem itself. How one obtains information can help in reducing costs. If data is readily available, the tools of regression, data analysis, non-parametric statistics and probability theory can be useful in providing a structured solution. On the other hand, if facts must be gathered, then other techniques may be used as well. Moody [11] suggests several non-mathematical means available including consensus thinking, brainstorming, the delphi principle, fish bowling, didactic interaction and collective bargaining. In addition to the above, other methods such as PERT (Program Evaluation and Review Technique) and QUID (Quantified Intrapersonal Decision Making) are becoming readily accessible.

B. APPLICATION OF RISK AND UNCERTAINTY TO THE PIF

During the funding process for Productivity Investment Funds (PIF), each project is checked for accuracy in its projections. Components requesting funds review and analyze past data on costs, workloads, etc., in an attempt to forecast

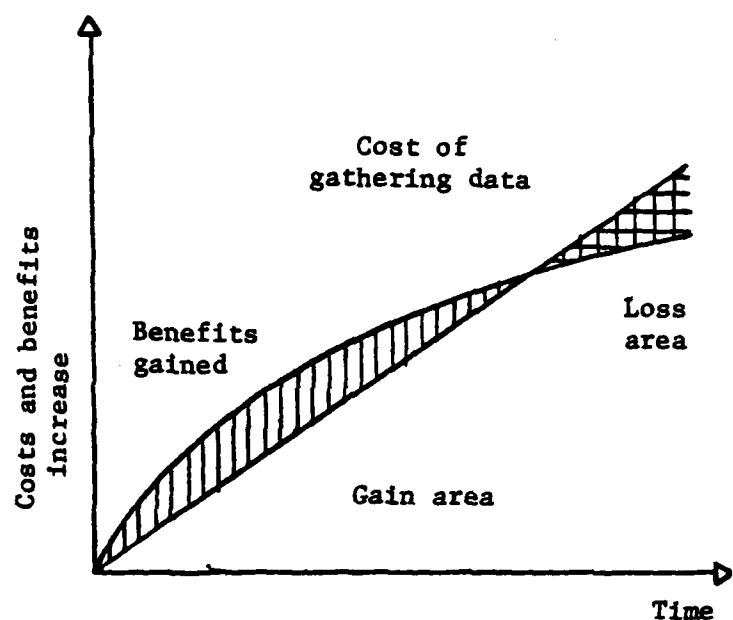


Figure 3 Cost-Benefit Time Curve

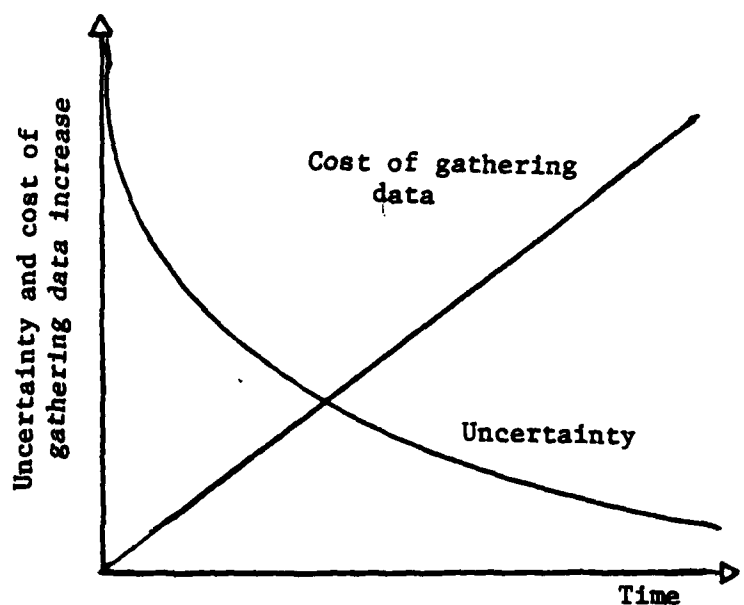


Figure 4 Cost-Uncertainty Time Curves

costs and savings into the future. These savings are the key to calculating such indicators as internal rate of return (IRR), return on investment (ROI), and investment per manpower space saved (INVPERSV). However cautious and meticulous an analyst or manager may be, these savings may or may not be realized. Techniques of risk and uncertainty may aid in taking futuristic inputs into account and better predicting savings. An example might best portray this statement.

Consider a machine that extracts rivets from aircraft wings at a rework facility. The investment cost of the machine is \$60,000. Since the cost incurred is in the very near future, it will be assumed to be accurate (providing installation costs, transportation costs, etc., have been incorporated). In the cost-benefit stream, savings are forecast to be \$30,000 per year for 10 years. Furthermore, assume the projected savings were based on a constant workload, that of the current level, throughout the economic life of the machine, i.e., 10 years. Clearly such factors as war, depression or recession, the introduction of a low maintenance aircraft, etc., could substantially increase or decrease the workload of the facility and, hence, projected savings. The list of factors that could affect the projections is practically endless. To construct a model incorporating all of these factors would be tedious and costly, with the model becoming unmanageable. If risk and uncertainty

were used on a macro level, most of these problems would be alleviated. (The word macro is used here to distinguish the analysis from a micro aspect.) The micro aspect of analysis would consider each factor, to achieve the final result. In the macro sense, one is concerned only with whether or not realized savings were above, below, or as projected without concern for the factors that would cause it to deviate. The macro model could enhance managability and still yield workable results, especially if not one, but 50 to 100 projects had to be dealt with.

The impact of risk and uncertainty in dealing with PIF projects should be apparent. The methodology and model used toward this end is presented in following chapters. It should be noted that the procedure used is not exclusive to investments alone, nor is it the only method applicable for analysis. Variations on this theme will also be mentioned later.

IV. AN ECONOMIC MODEL

A. DEFINITIONS

The underlying motive of any business is to make a profit. One method of achieving this is through capital investments. It follows that managers expect money invested today to increase in amount as time passes because they expect to earn a profit on that investment. To the manager, therefore, the value of money today is more than its value at some future time. Anthony and Reese [1] make an interesting analogy, "An investment is thus the purchase of a future stream of expected cash inflows" [2: pg. 710]. Cash inflows are simply earnings or savings.

If several investment alternatives exist, then a basic criterion must be established for the purposes of comparison and evaluation. Although five criteria are explained next, only three (IRR, ROI, INVPERSV) are used by DPPO.

The first economic indicator, Net Present Value (NPV), is the difference in the present value of the benefits (savings) and the present value of the costs at a given discount rate (the interest rate used to discount or calculate future costs and benefits so as to arrive at their present values). Mathematically, this may be expressed as:

$$NPV = \sum_{t=1}^n \frac{S_t}{(1+k)^t} - A_0, \quad (2)$$

where:

A_0 = present value of the cost of the project,

S_t = savings received in period t ,

k = appropriate discount rate,

t = time period, and

n = useful life of asset.

If A_0 is incurred over a period of time, then

$$A_0 = \sum_{t=1}^n \frac{A_t}{(1+k)^t}, \quad (3)$$

where A_t is the cost during period t . If the NPV is positive, it means the project is expected to yield a return in excess of the required rate. If it is zero, the yield is expected to equal the required rate.

The discount rate that equates the present value of the future cash flows with the present value costs of an investment is known as the Internal Rate of Return (IRR). This is calculated by determining the discount rate that will make the NPV zero:

$$\sum_{t=1}^n \frac{S_t}{(1+r)^t} - A_0 = 0, \quad (4)$$

where:

r = IRR,

S_t = savings received in period t ,

t = time period,
 A_0 = investment cost, and
 n = useful life of asset.

If cash inflows are uneven, the trial and error method is recommended. Computers ease the tediousness of the computation; however, DoD has derived a more simplistic procedure. Dividing the project cost by the average annual savings will yield a factor. This factor and the number of years in the economic life of the project can be used to enter a table and select the IRR. If the cash inflows are even, Anthony and Reese [1], using the same calculation, offer the IRR based upon the same table inputs.

The Payback Period (P-P) refers to the number of periods required for the (undiscounted) cumulative cash inflows to have the same value as the investment cost.

Another indicator, Return On Investment (ROI), is synonymous with the savings to investment ratio. This method compares yearly income of a project with the investment in the asset [1: pg. 52]. The formula used by DPPO is:

$$\text{ROI} = \frac{\sum_{t=1}^n S_t}{\sum_{t=1}^n C_t} \quad (5)$$

where:

S_t = savings received in period t

C_t = costs incurred in period t
 t = time period
 n = useful life of the asset.

Finally, the Investment Per Manpower Space Saved (INVPERSV) is simply an indicator that compares cost to manpower. A manpower space is best defined by example. If two clerks are required to perform a task, and the introduction of a new system requires only one of them, then the other is freed and can be assigned elsewhere. This equates to saving one manpower space.

B. THE MODEL

Although the techniques of both risk and uncertainty have been discussed, the model that will be presented next will deal strictly with uncertainty. This is not to say that the model could not be used with risk. After careful analyses of several audit reports, there was not enough information to derive probability distributions, thus eliminating the introduction of risk. In particular, the audit reports, for the most part, failed to compare actual (or realized) costs or savings to that which was proposed. Without this information, it would be extremely difficult to obtain probability distributions (the use of subjective probabilities could have been used). Further discussion on this point is contained in Chapter VI.

In the process of evaluating and ranking PIF projects, DPPO used three indicators; IRR, ROI and INVPERSV. The

model, therefore, will contain three submodels used to evaluate each indicator respectively. A tree diagram was used in each submodel in order to present the different outcomes in an orderly fashion. Figures (5), (6) and (7) are graphical representations of these models. The underlying assumption used in the development of each diagram is based on the independence of cost, savings, manpower space saved (MPS) and cash flow. The term independence is used to signify that an outcome of one variable is not dependent on any of the others. This assumption allows one to branch out the different future states of nature and then apply uncertainty techniques.

It should be noted that the IRR model utilizes one branch instead of two as represented in the other models. This was done for two reasons. The first is that Sciortino's [1] audit of FASCAPs (Fast-Payback Capital Investments) revealed that 11.7 percent of all funded projects resulted in cost overruns of 10 percent of the total projected cost. This sum did not appear to be significant in comparison to the total cost of all of the funded projects. Secondly, the program used to evaluate the model was written in APL (A Programming Language). The IRR computation was derived through an iterative loop which, in APL, can be costly due to the limitations of APL's capabilities (one run of 15 projects takes approximately 10 minutes, equating to a cost of nearly \$80.00). Comparing the cost of computation to the benefits

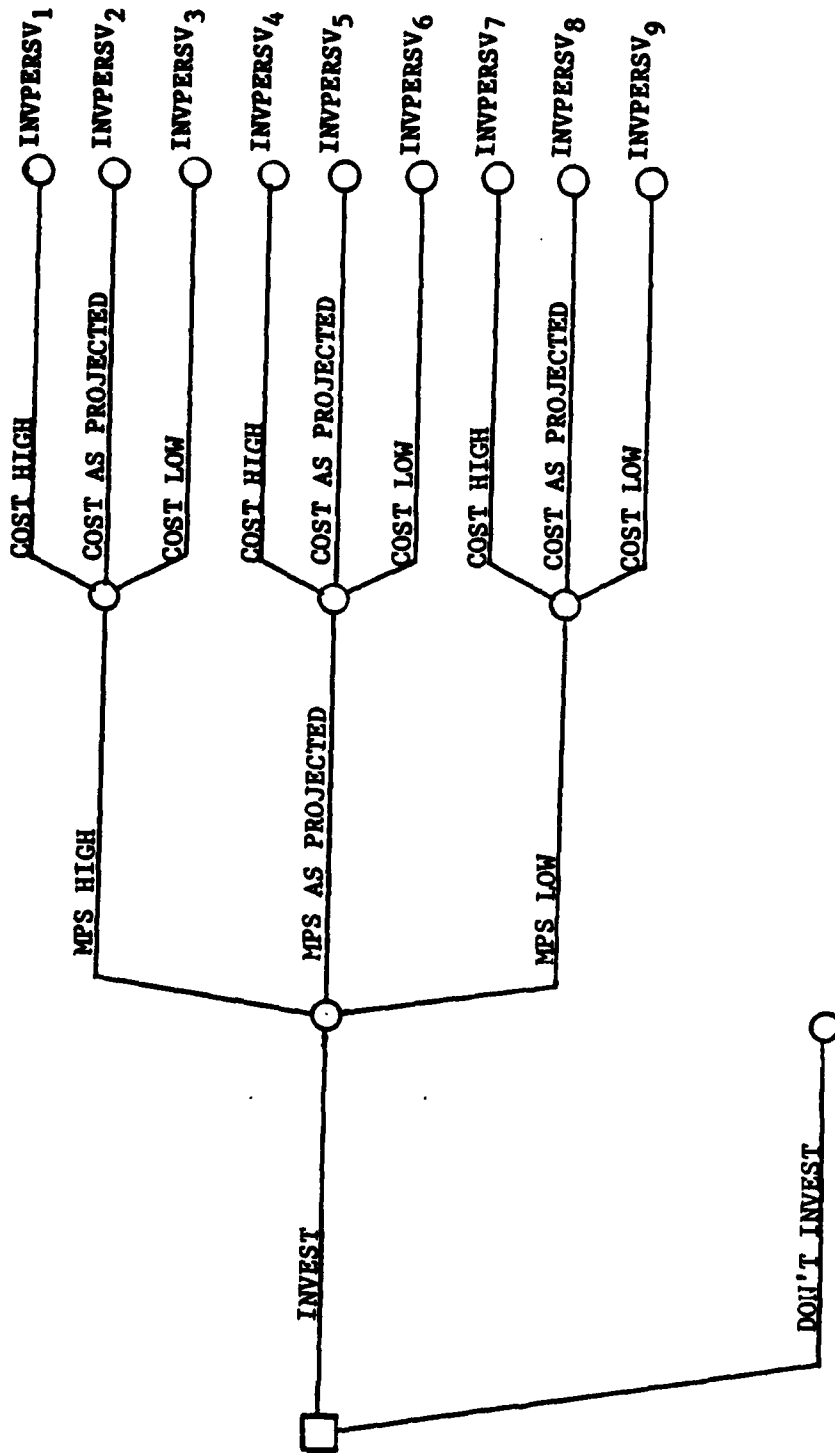


Figure 5. INVPSV Submodel

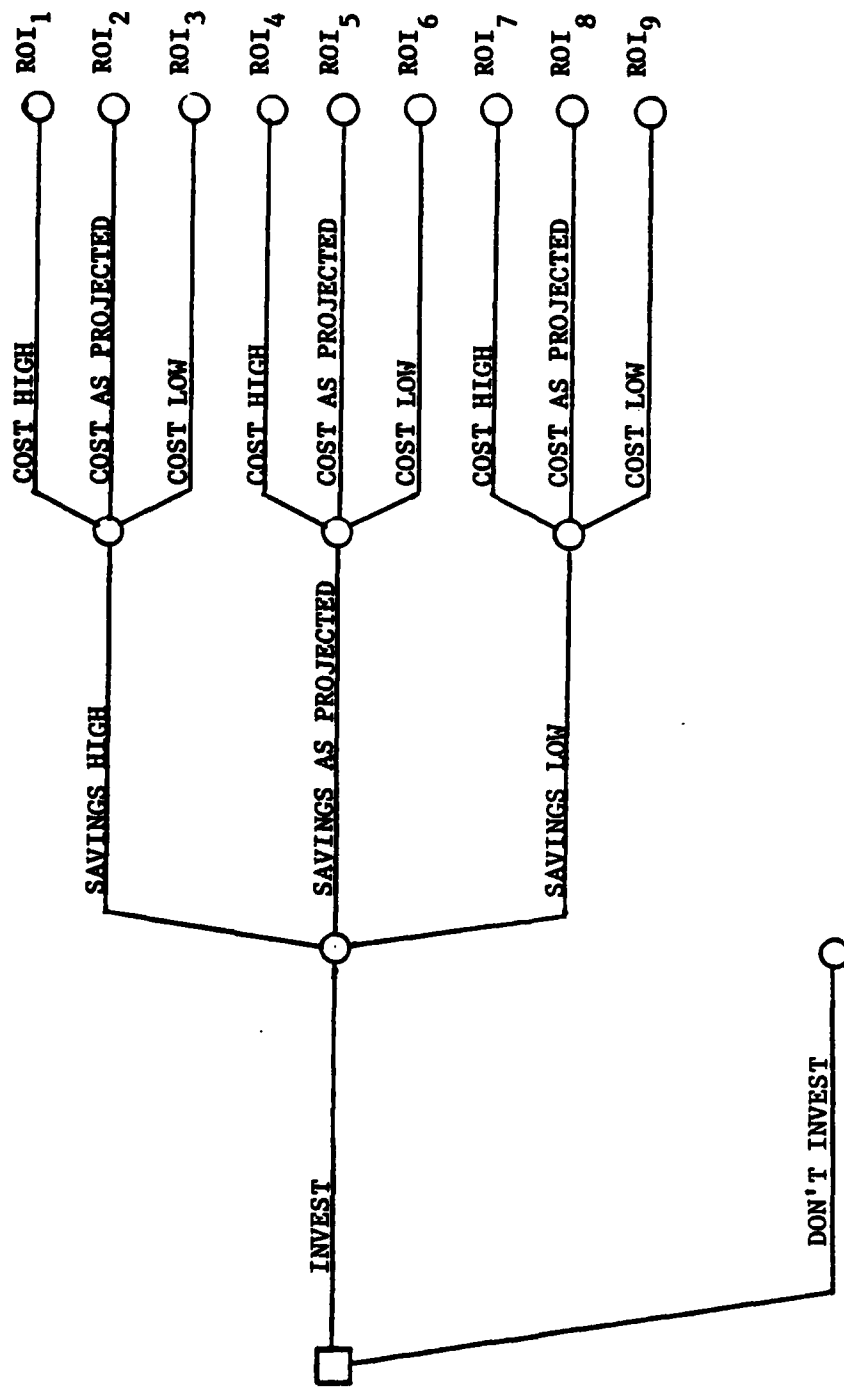


Figure 6. ROI Submodel

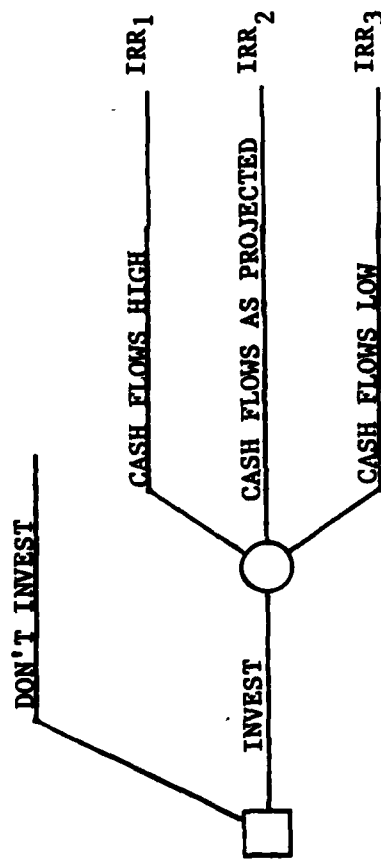


Figure 7. IRR Submodel

derived from the additional branching, it was felt that one branch was adequate.

As previously stated, the main model was broken down into three submodels, one for each indicator to be ranked. Once the program has computed the branch values in each submodel, it proceeds to apply the techniques that deal with uncertainty, in particular, the MAXIMIN, MAXIMAX and LaPlace principles.

The MAXIMIN principle may be viewed as a pessimistic approach. This principle of choice suggests that the maximum of the minimum gains be chosen, or select the best of the worst outcomes. In this section of the program, the minimum value of each submodel is selected and stored in three vectors (one for each indicator). These vectors are then placed in a 47^1 by 3 matrix where the rows represent projects and the columns are the respective indicators. A value in the matrix is the minimum value for an indicator peculiar to a project. Once this matrix is complete, each column (or indicator) is ranked from highest to lowest (i.e., the greatest number receives rank one, and so on). In the event of a tie, an average rank is used. These rankings are then placed in another matrix which will be referred to as the rank matrix. The ranks are then summed across the columns (indicators) and then re-ranked from lowest to highest. By summing across the columns, one is merely adding the ranks

¹There are 47 PIF projects funded in FY84. These projects form the data base.

of the indicators for each project. Subsequently, the project with the lowest combined rank is the best project and hence the reason to rank from the lowest (rank one) to the highest. The result of this procedure is a vector of 47 elements (one for each project) representing the final ranking.

The second technique used is the MAXIMAX principle. This is an optimistic approach where the best possible outcome is maximized. The procedure used here is identical to the MAXIMIN computation with the exception that the maximum value in each submodel is chosen instead of the minimum.

The LaPlace principle is computed somewhat differently. This method assumes that the branch values are equally likely to occur within each submodel. Using this probability distribution, an expected value for each indicator can be derived. The result is a matrix of expected values for each project and indicator. This matrix is then ranked using the same procedure as previously discussed.

The ultimate product of the program is a matrix of the final rankings of each product using each of the three methods of uncertainty. It is now possible to judge the effect of uncertainty by comparing these rankings to those derived using DPPO's procedure. However, before these results are revealed, some discussion on software support for the model and problems that arose during the development of the model warrant attention.

C. SOFTWARE SUPPORT

In the process of evaluating the model, two data files were created and several functions and programs written. The first file, THESISD, is a 47×5 matrix where the rows represent the projects and the columns are total cost, total savings, manpower spaces saved, NPV, and economic life. CFMATRIX is the second file containing the cash flows for each project over a period of 28 years. To ensure matrix conformability, zeroes had to be added to those projects whose economic lives were less than 28 years. These zeroes are removed in the main program to reduce computations.

The main program, UNCERT, is written in APL and calls its data from the two files. It internally computes ROI and INVPERSV branch values, selects max and min values and calls other functions for IRR values (CALIRR) and to perform rankings (RANKUP, RANKDN). A listing of UNCERT as well as the functions are contained in Appendix (A). Copies of the base data composes Appendix (B).

D. PROBLEM AREAS

In the development and documentation of the model, several problems were encountered which substantially altered the procedure to be used.

The first difficulty concerned itself with the INVPERSV computation. The formula used by DPPO can be expressed as

$$\text{INVPERSV} = \frac{\text{Total Cost}}{\text{Manpower Spaces Saved (MPS)}} \cdot \quad (6)$$

This presents two problems. First, if MPS is zero, INVPERSV is undefined (an MPS of zero is not uncommon). To correct this deficiency, DPPO arbitrarily sets INVPERSV equal to 9999.99. Secondly, if MPS is between zero and 1, then INVPERSV is greater than the total cost. Currently, there is no correction for this. Another difficulty with this indicator lies in its lack of logical attractiveness. Explicitly, IRR and ROI are benefits which implies bigger is better. INVPERSV, as presently used, is a cost (bigger is bad). Although the procedure used by DPPO takes this into account, it is felt that the indicator contradicts the logical flow when used with the other indicators.

A second problem arose when trying to duplicate DPPO's calculations of IRR. Using Equation (4) and assuming the cash inflows were present value (verified by DPPO to be correct), the IRR's obtained from CALIRR differed from those calculated by DPPO.

Another minor discrepancy involved the value for economic life. THESISD contained one value, however, when calculating IRR, different economic lives were obtained using the cash inflow information. This had no effect on calculations since IRR used strictly cash flow information.

Concern was additionally raised due to the fact that DPPO's final ranking could not be reproduced. Further discussions on this point are unnecessary since modifications to the analysis to be performed would create new rankings, thus eliminating any reason to duplicate the original ranked list.

E. PROCEDURE

At this point the reader should have an understanding of the model, how uncertainty will be introduced, and some problems that were encountered in the process. This section will: a) discuss how the INVPERSV problem was solved, b) explain how deviation levels were obtained, c) how the IRR confusion was treated and d) given an outline for sensitivity analysis that will be performed.

The first topic is how to correct the INVPERSV problem. If the original indicator yielded a cost, then the inverse of the indicator would be a benefit. Additionally, the inverse would also alleviate the problem of dividing by zero or a fraction. However, the inversion of the indicator results in a decimal. By scaling the result (multiply by 1000), the indicator becomes more readable and comparable to the other indicators. This transformation is given by:

$$\text{INVPERSV} = \left(\frac{\text{Total Manpower Spaces Saved}}{\text{Total Cost}} \right) \times 1000 . \quad (7)$$

Take, for example, an INVPERSV of 275.0. The inverse would be 0.0036. Scaling by 1000 yields 3.6. Several things should be noted. First, using a scalar of 1000 is purely arbitrary. Any scalar could have been used. Secondly, by inverting the indicator, the ranking must be done from highest to lowest. This did not change the original ranking done by DPPO. The final point is that by inverting, the

logical attractiveness of INVPERSV is achieved. The reason for scaling is discussed more in Chapter VI but deals with an alternate means of obtaining a ranking.

In Section C, the idea of changing different variables (i.e., cost, savings, etc.) was introduced. How much to vary these variables is what is of interest here. In the program, deviation levels are represented as a vector with three elements. These elements represent variables above the projected level, as projected, and below projected levels. That is to say, if a cost overrun were to occur, the average overrun would be, for example, 20 percent of the projected cost. This can be mathematically expressed as, cost overrun = $1.2 \times$ projected cost. Similarly, to maintain the projected cost, a multiplier of 1 is used while a number less than 1 would relate a cost underrun. Deviation levels can be determined by

$$\text{Cost Deviation} = \frac{\text{Actual Cost}}{\text{Projected Cost}} \cdot \quad (8)$$

By using Sciortino's [1] audit and Equation (8), deviation levels for cost, savings, and cash flows were obtained. Manpower variations, however, were purely subjective. In reviewing several audit reports, there is no data to address this point. The deviation levels used to obtain variations were 1.1 for a manpower overrun and 0.9 for an underrun. The sensitivity analysis that will be performed later will further address this area.

IRR fluctuations created an area of concern since they could not be duplicated and since the results obtained using Equation (4) showed no correlation to DPPO's data. To remedy the situation, all 47 projects were ranked using Equation (4) to calculate IRR and Equation (7) for INVPERSV (ROI calculations were the same). The results of this run will be referred to as the DPPO Base since this is what the rankings should have been with all problems aside. Next, a run was made to introduce uncertainty. These results were compared to the DPPO Base to see if any significant changes had taken place. For reference, Appendix (C) is the DPPO Base case and Appendix (D) displays the results after uncertainty was applied.

In order to examine which variables and uncertainty methods were critical, sensitivity analysis was performed. The variables of concern are cost, savings and manpower spaces saved. Initially, single variables were used, followed by changes in two variables and finally, by three. Appendix (E) contains the results of these runs while the next chapter discusses this issue in greater detail.

V. RESULTS

A. INITIAL COMPARISON

DPPO's ranking was computed using the new INVPERSV and IRR ranking. The base case, which introduces uncertainty into the ranking, was run using deviation levels outlined in Table I. These values were obtained using Sciortino's [1] audit and Equation (8). The output of the two runs were then compared to determine if the base case had any impact on DPPO's ranking.

TABLE I

Deviation Levels Used in the Base Case

	<u>Above Projected</u>	<u>Below Projected</u>
Cost	1.256	0.825
Savings/ Cash Flows	1.014	0.3116
Manpower Spaces	1.1	0.9

Before any comparison may be undertaken, it might be beneficial to define how this impact is to be measured. Three terms are used to judge the magnitude of difference between DPPO's ranking and the base case; 1) significant (S) implies that 5 or more projects experienced any rank jumps or any

two projects had jumps of 5 ranks or more, 2) slightly significant (SS) is defined as 3 or more projects had rank jumps or any two projects had jumps of three ranks or more, and 3) no significance (NS) merely represents any situation less than those described above.

Initially, all 47 projects were compared. This revealed that the MAXIMIN and LaPlace Principles significantly changed the rankings while the MAXIMAX showed little to no change. DPPO's rankings were divided into three groups; projects 1 through 15, 16 through 31 and 32 through 47. The reason for subdividing was to observe where the jumps in ranking occurred. A summary of the results is contained in Table II.

TABLE II
Summary of Initial Comparison

<u>Project Number</u>	<u>MAXIMIN</u>	<u>LaPlace</u>	<u>MAXIMAX</u>
All	S	S	NS
1-15	SS	NS	NS
16-31	S	SS	NS
32-47	S	S	NS

Using this information, it is evident that jumps occur more frequently in the lower projects. The reason for this occurrence is primarily due to the first 15 projects offering significantly greater IRRs, ROIs, and INVPERSVs than the

others. This information will play a role in performing sensitivity analysis and therefore the discussion will be delayed until then.

B. SENSITIVITY ANALYSIS

Due to cost constraints in running all 47 projects, only the first 15 were used to perform sensitivity analysis. To begin, a new base case dealing with uncertainty was derived and would be used to compare 24 variant runs. The purpose of this analysis was to determine which variables were critical and which uncertainty methods were sensitive to the changes. First, single variable deviations were analyzed, followed by two and three variable combinations.

The results of the initial runs with single variables indicated that all three methods were insensitive to minor changes in the variables with one exception. This run dealt with increasing the bounds (above projected and below projected deviation levels) of savings by 20 percent and creating significant rank jumps in the MAXIMIN ranking and slightly significant jumps in that of LaPlace.

The deviation levels were then preset to values outlined in Table III. It should be noted that these levels are substantial deviations from the projected values. This is primarily due to the nature of the first 15 projects. As mentioned in Section A of this chapter, the initial comparison noted little change in ranking among the three methods. This is attributable to the large variations in each of the

TABLE III

Deviation Levels Used in Sensitivity Analysis

	<u>Above Projected</u>	<u>Below Projected</u>
Cost	2.512	0.2
Savings/ Cash Flows	2.0	0.1
Manpower Spaces	2.2	0.2

variables in the first 15 projects as compared to the rest. These variations are presented in Table IV. Due to restrictions in programming, other projects could not have been selectively chosen without redrafting files. However, despite this problem, it is still possible to determine critical variables and sensitive methods.

Table V conveniently summarizes the results obtained from the analysis. A word on notation though, might aid in its understanding. In the description column, the variable being changed is described as being either high or low. High refers to an increase in the above projected deviation level only while low, decreases the below projected level. Run 2b decreased both bounds by a set percent and Run 3b increased both bounds. As stated earlier, other runs utilizing this procedure yielded no changes with the exception of 3b and, therefore, eliminated further use of the procedure.

To further summarize the contents of Table V, it can be said that the LaPlace principle was the most sensitive to

TABLE IV

Statistical Summary of Projects

Project Number	Mean	Cost Std. Dev.	Mean	Savings Std. Dev.	Manpower Spaces Mean Std. Dev.	Economic Life Mean Std. Dev.
All	1603.6	3717.4	22701	45826	50.211 143.260	12.404 7.0669
1-15	3500.2	6072.2	52358	72045	96.400 187.150	14.267 8.5979
16-31	464.2	483.0	8565	13117	8.288 17.762	11.625 4.9929
32-47	965.1	1519.6	9034	11474	48.831 161.02	11.438 4.9929

TABLE V

Summary of Sensitivity Analysis

Run Number	Description	MAXIMIN	LAPLACE	MAXIMAX
1	Cost High	NS	NS	NS
2a	Cost Low	NS	SS	NS
3a	Savings High	NS	SS	NS
3b	Savings Low	SS	SS	NS
4	MPS High	SS	SS	NS
5	MPS Low	SS	SS	NS
6	Cost High	NS	SS	NS
7	Cost Low	NS	SS	NS
8	Savings High	SS	SS	NS
9	Savings Low	SS	SS	NS
10	Cost High	NS	SS	NS
11	Cost Low	NS	SS	NS
12	Savings High	SS	SS	NS
13	Savings Low	SS	SS	NS
14	MPS High	SS	SS	NS
15	MPS Low	SS	SS	NS
16	Cost High	NS	SS	NS
17	Cost Low	NS	SS	NS
18	Savings High	SS	SS	NS
19	Savings Low	SS	SS	NS
20	Cost High	NS	SS	NS
21	Cost Low	NS	SS	NS
22	Savings High	SS	SS	NS

NS - Not Significant
SS - Slightly Significant
S - Significant

change. This may be attributed to the cost-savings relationship and, in particular, savings deviations. This would affect both the ROI and IRR. The method was insensitive to manpower variations. The only other method to show a reaction was MAXIMIN. This is strongly evident in low savings cases. Low savings (implying low cash flows) will, in turn, drive IRR with an additional effect on ROI. Once again, manpower fluctuations had little to no effect. The last principle, MAXIMAX showed little to no change during the course of the analysis.

To summarize, the LaPlace principle showed sensitivity to more variables or combinations thereof. The MAXIMIN method was the only technique to cause significant jumps in rankings. With both methods, savings seemed to be the critical variable indicating that IRR is the main driver in the rankings, followed by ROI. INVPERSV had little to no effect in the rankings.

VI. CONCLUSIONS AND REMARKS

A. CONCLUSIONS

Since the objective of this thesis was to determine if the methods of risk and uncertainty could change project rankings from the present procedure, this point shall be addressed first. It is apparent that both the MAXIMIN and LaPlace principles will change the ranking and their incorporation into the present procedure should be investigated as a short term solution. Additionally, the LaPlace approach is recommended above the others for several reasons: It is not an extreme selection; it makes more use of the different outcomes than the other methods; and it is more sensitive to the variables and combinations thereof.

This paper does not purport to advocate strict adherence to methods of uncertainty in decision making. The use of risk is a better solution to solving problems of this nature. To enable the use of risk techniques, it is recommended that audit reports compare realized costs, savings, and manpower to that which was projected. Furthermore, since DPPO maintains a data base from which the projects are ranked, this data base should also serve as a reference in doing audits. As mentioned before, audit reports should also address manpower spaces, which to this point, has gone without remark.

The use of the new INVPERSV and IRR equation have been discussed sufficiently. Their incorporation into the present procedure is highly recommended.

The use of equal weights for the indicators is another questionable area, and will be addressed in the final section of this chapter.

Although more conclusions could be drawn, the next section will introduce a corrective procedure which would provide better and more accurate rankings.

B. REMARKS

The content of this thesis introduced the use of risk and uncertainty into DPPO's procedure. This is what it was commissioned to do; however, a better approach utilizing multiattribute utility theory may prove to provide quite different results.

The present procedure has several flaws. The first is using linear combinations of rankings to obtain a final aggregate ranking. Economic indicators are measures of effectiveness (MOEs). These MOEs have a common origin (zero) and are measured on a ratio scale, meaning a statement may be made to the effect that one IRR is twice as good as another IRR.

The use of ranks, changes the scale to ordinal and this information is lost. An example may best illustrate this point. Suppose a comparison of projects A and B is to be made. Project A has an IRR of 200 percent, an ROI of 87

percent and an INVPERSV of 78. Project B, on the other hand, has an IRR of 25 percent, an ROI of 88 percent and an INVPERSV of 79. According to the present procedure, project B is better. However, if a ratio scale is used, then project A would be the wiser choice since A's IRR is 8 times greater than B's with the other indicators about equal.

Additionally, the sensitivity analysis pointed out that IRR seemed to drive the rankings with ROI having a smaller input. This indicates that the use of equal weights may not be as reasonable as initially thought.

This topic should be considered an area for future study. The benefits derived from it could be substantial and lead to a more effective manner to judge projects and eventually realize their benefits.

APPENDIX A

SOFTWARE SUPPORT

This appendix contains the programs used to introduce uncertainty to the Productivity Investment Fund.

```

[1]  ▽ UNCERT
[2]  'RUN NUMBER: DPPD BASE'
[3]  A
[4]  A INPUT DEVIATION LEVELS
[5]  A
[6]  COSTD←1
[7]  SAVD←1
[8]  CFD←1
[9]  MPD←1
[10] A
[11] 'DEVIATION LEVELS:'
[12] COST : : TCOSTD
[13] SAVINGS : : TSAVD
[14] MANPOWER : : TMPD
[15] CASHFLOWS : : TCFD
[16]
[17] Q←'INPUT TOTAL NO OF PROJECTS TO BE RANKED.'
[18] TN←Q
[19] I←0
[20] MAXIRR←MAXROI←MAXMPD←LROI←LMPD←0×(1TN)
[21] MINIRR←MINROI←MINMPD←9999×1+0×(1TN)
[22] LIRR←LROI←LMPD←0×(1TN)
[23] L1←I+1
[24] A INSERT DATA
[25] COST←,THEISD[I;1]
[26] SAV←,THEISD[I;2]
[27] MPD←,THEISD[I;3]
[28] NPV←,THEISD[I;4]
[29] CF←,CFMATRIX[I;]
[30] A
[31] 'PROJECT NUMBER: ',I
[32] A
[33] 'INPUT VARIABLES:'
[34] TOTAL COST : : TCOST
[35] TOTAL SAVINGS : : TSAV
[36] MANPOWER SAVED : : TMPD
[37] A
[38] A DELETE 0'S FROM CF VECTOR
[39] A
[40] CF←DROP CF
[41] CASH FLOWS : : TCF
[42]
[43]
[44] A
[45] A COMPUTE BRANCH VALUES
[46] A
[47] COSTS←COST×COSTD
[48] SAVS←SAV×SAVD
[49] MPSS←MPD×MPD
[50] COUNT←COSTS
[51] A
[52] A SELECT THE VALUES FOR EACH OF THE PROJECTS
[53] ROI MPS'
[54] A
[55] EROI←EMPD←0×19
[56] J←L+0
[57] L2←J+J+1
[58] K←0
[59] L3←K+K+1
[60] L←L+1
[61] EROI[L]←SAVS[J]÷COSTS[K]
[62] EMPD[L]←(MPSS[J]÷COSTS[K])×1000
[63] EROI[L] AND EMPD[L]
[64] →(K(COUNT))/L3
[65] →(J(COUNT))/L2
[66] A
[67] A COMPUTE IRR VALUES
[68] A
[69]

```

```

[70]
[71] CALIRR CF
[72] A
[73] A APPLY LAPLACE METHOD
[74] A
[75] LROI[I]+LAPLACE EROI
[76] LMPS[I]+LAPLACE EMPS
[77] LIRR[I]+LAPLACE EIRR
[78] A
[79]
[80] 'LAPLACE VALUES FOR ROI IRR AND MPS'
[81] LROI[I] AND LIRR[I] AND LMPS[I]
[82] A SELECT MAX AND MIN
[83] A
[84] MAXROI[I]+([/EROI)
[85] MAXIRR[I]+([/EIRR)
[86] MAXMPS[I]+([/EMPS)
[87] MINROI[I]+([/EROI)
[88] MINIRR[I]+([/EIRR)
[89] MINMPS[I]+([/EMPS)
[90] +((I(TN)/L1
[91]
[92] MAXROI MINROI MAXIRR MINIRR MAXMPS MINMPS'
[93] MAXROI AND MINROI AND MAXIRR AND MINIRR AND MAXMPS AND MINMPS
[94] A
[95] A RANK THE INDICATORS
[96] A
[97] A APPLY MAXIMIN CRITERIA
[98] RANK1+RANKUP MINROI
[99] RANK2+RANKUP MINMPS
[100] RANK3+RANKUP MINIRR
[101] MATRIX1+RANK1 AND RANK2 AND RANK3
[102] FINAL1+(/MATRIX1
[103] FINRANK1+RANKDN FINAL1
[104] A
[105] NO+1TN
[106] A
[107] RANK4+RANKUP LROI
[108] RANK5+RANKUP LMPS
[109] RANK6+RANKUP LIRR
[110] MATRIX2+RANK4 AND RANK5 AND RANK6
[111] FINAL2+(/MATRIX2
[112] FINRANK2+RANKDN FINAL2
[113] A
[114] RANK7+RANKUP MAXROI
[115] RANK8+RANKUP MAXMPS
[116] RANK9+RANKUP MAXIRR
[117] MATRIX3+RANK7 AND RANK8 AND RANK9
[118] FINAL3+(/MATRIX3
[119] FINRANK3+RANKDN FINAL3
[120] A
[121]
[122] 'THE FINAL RANKINGS LISTED BY METHOD:'
[123] 'PROJ MAXIMIN LAPLACE MAXIMAX'
[124] NO AND FINRANK1 AND FINRANK2 AND FINRANK3

```

```

      ▽CALIRR[0]
      ▽ Z←CALIRR X
[1]  LIMIT←0.01×COST
[2]  EIRR←0×13
[3]  ELIFE←pX
[4]  CAL←0×(1ELIFE)
[5]  'IRR VALUES:'
[6]  II←0
[7]  L1: II←II+1
[8]  JJ←0
[9]  R←0.3
[10] CFS←X×CFD[II]
[11] L2: R←R+0.001
[12] JJ←0
[13] L3: JJ←JJ+1
[14] CAL[JJ]←CFS[JJ]÷((1+R)*JJ)
[15] →(JJ<ELIFE)/L3
[16] ANS←+/CAL
[17] CALSUM←ANS-COST
[18] UPPER←CALSUM+LIMIT
[19] LOWER←CALSUM-LIMIT
[20] →((LOWER<0)^(UPPER>0))/L4
[21] →(CALSUM>0)/L2
[22] R←(R-0.105)
[23] →L2
[24] L4: EIRR[II]←R
[25] EIRR[II]
[26] →(II<3)/L1
      ▽

```

```

      ▽CONVERT[0]
      ▽ Z←CONVERT X
[1]  COST←.THESISD[:1]
[2]  IND←0×147
[3]  I←0
[4]  L1: I←I+1
[5]  IND[I]←X[I]÷COST[I]
[6]  →(I<47)/L1
      ▽

```

```

      ▽LAPLACE[0]
      ▽ Z←LAPLACE X
[1]  INDEX←pX
[2]  P←1÷INDEX
[3]  AVG←+/(VAL+X×P)
[4]  Z←AVG
      ▽

```

```

      ▽RANKUP[0]▽
      ▽ Z←RANKUP X
[1] Y←X[↑X]
[2] INDEX←pY
[3] I←0
[4] ANS←R←0×1pY
[5] L1:I←I+1
[6] J←0
[7] L2:J←J+1
[8] ANS[J]←(X[I]=Y[J])
[9] →(J<INDEX)/L2
[10] DUP←+/ANS
[11] →(DUP>1)/L3
[12] R[I]←ANS11
[13] →(I<INDEX)/L1
[14] →L99
[15] L3:XX←[ /T←+ \ANS
[16] YY←1XX
[17] F←0×1XX
[18] L←0
[19] L4:L←L+1
[20] F[L]←T1L
[21] →(L<XX)/L4
[22] RT←+/F÷pF
[23] R[I]←RT
[24] →(I<INDEX)/L1
[25] L99:Z←R

```

```

      ▽
      ▽DROP[0]▽
      ▽ Z←DROP X
[1] Y←4↑X
[2] Z←4↓X
[3] INDEX←(Z≠0)
[4] XX←INDEX/Z
[5] Z←Y,XX
      ▽

```

APPENDIX B

DPPO'S DATA FILE

This appendix contains the data used to perform the analysis.

Project No	Total Cost	Total Savings	Manpower Saved	NPV	Economic Life
1	572.5	25445.0	9.0	16706.3	5
2	21178.4	154800.0	472.0	72663.3	8
3	5542.2	130072.5	272.0	33482.7	25
4	268.0	6151.0	4.0	3886.3	5
5	629.9	16255.0	0.0	4247.0	25
6	1033.8	5016.7	52.6	2137.9	7
7	784.2	20067.5	0.0	5838.7	25
8	1026.4	28292.5	0.0	8311.0	25
9	1711.7	27529.6	0.0	8820.0	20
10	468.8	2531.0	38.9	1450.0	5
11	14345.0	253374.1	573.0	126215.9	8
12	1894.5	37600.0	0.0	19107.9	10
13	788.5	9198.0	7.0	2770.6	20
14	240.0	3828.0	3.0	1241.2	20
15	2020.0	65214.1	14.5	39210.2	6
16	147.7	1499.0	5.0	689.6	10
17	138.7	1873.5	0.0	1041.7	10
18	126.0	1757.2	0.0	966.2	8
19	245.2	1314.4	5.0	568.7	10
20	1871.7	52637.2	0.0	15621.3	28
21	535.3	5863.0	0.0	3067.0	10
22	476.2	5301.1	0.0	2876.9	7
23	161.6	1774.5	12.0	1183.7	5
24	135.0	10557.5	0.0	3697.8	25
25	290.0	1421.0	16.0	609.8	7
26	4420.0	8763.0	0.0	4964.2	10
27	1351.1	14999.1	72.0	9803.3	5
28	616.9	21710.0	0.0	7264.6	25
29	363.9	2647.7	11.4	1217.4	10
30	370.0	3439.7	7.6	1866.2	8
31	177.0	1480.0	3.0	809.9	8
32	173.1	1897.0	11.8	502.5	25
33	861.3	8366.0	13.7	3811.6	10
34	520.0	12789.0	1.5	5964.4	15
35	908.7	7200.0	6.5	3456.7	8
36	298.7	2361.6	18.0	1276.1	8
37	935.0	6700.0	44.4	3411.6	8
38	199.0	2460.0	15.0	1301.9	10
39	635.0	4768.0	15.0	2544.4	8
40	143.3	940.8	3.3	427.0	8
41	262.0	12060.0	0.0	5296.9	15
42	3182.5	23260.0	65.2	12142.0	8
43	870.0	45950.0	4.0	21875.3	10
44	121.0	9427.4	13.6	3854.6	12
45	105.8	672.0	2.0	327.1	8
46	294.9	828.0	2.5	246.6	20
47		4857.0	2.0	2418.0	10

Summary of Cash Inflows for Each Project for 28 Years

Year	Project Number	1	2	3	4	5	6	7	8	9	10
1	1	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
2	2	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
3	3	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
4	4	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
5	5	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
6	6	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
7	7	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
8	8	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
9	9	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
10	10	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
11	11	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
12	12	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
13	13	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
14	14	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
15	15	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
16	16	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
17	17	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
18	18	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
19	19	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
20	20	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
21	21	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
22	22	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
23	23	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
24	24	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
25	25	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
26	26	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
27	27	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555
28	28	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555	5555555

Year	Project Number	11	12	13	14	15	16	17	18	19	20
1	33	912	2	59	1	3	149	13	89	15	1879
2	31	51	7	45	1	6	149	19	208	29	1879
3	31	51	7	45	1	6	149	22	208	29	1879
4	31	51	7	45	1	6	149	15	208	29	1879
5	31	51	7	45	1	6	149	15	208	29	1879
6	31	51	7	45	1	6	149	15	208	29	1879
7	31	51	7	45	1	6	149	15	208	29	1879
8	31	51	7	45	1	6	149	15	208	29	1879
9	31	51	7	45	1	6	149	15	208	29	1879
10	31	51	7	45	1	6	149	15	208	29	1879
11	31	51	7	45	1	6	149	15	208	29	1879
12	31	51	7	45	1	6	149	15	208	29	1879
13	31	51	7	45	1	6	149	15	208	29	1879
14	31	51	7	45	1	6	149	15	208	29	1879
15	31	51	7	45	1	6	149	15	208	29	1879
16	31	51	7	45	1	6	149	15	208	29	1879
17	31	51	7	45	1	6	149	15	208	29	1879
18	31	51	7	45	1	6	149	15	208	29	1879
19	31	51	7	45	1	6	149	15	208	29	1879
20	31	51	7	45	1	6	149	15	208	29	1879

Cash Inflows (Con't)

Year	21	22	23	24	25	26	27	28	29	30
Project Number										
1	586:3	764:5	354:9	422:3	202:9	876:3	2249:8	868:4	125:9	356:5
2	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	367:4
3	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	389:8
4	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	412:5
5	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	437:7
6	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	463:5
7	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	491:5
8	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	521:0
9	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
10	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
11	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
12	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
13	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
14	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
15	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
16	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
17	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
18	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
19	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
20	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
21	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
22	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
23	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
24	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
25	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
26	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
27	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
28	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
29	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0
30	586:3	756:1	354:9	422:3	202:2	876:3	2999:8	868:4	280:2	000:0

Cash Inflows (Con't)

Year	31	32	33	34	35	36	37	38	39	40
1	185	86	83	85	900	295	400	22	596	117
2	185	86	83	85	900	295	900	23	596	117
3	185	86	83	85	900	295	900	25	596	117
4	185	86	83	85	900	295	900	25	596	117
5	185	86	83	85	900	295	900	25	596	117
6	185	86	83	85	900	295	900	25	596	117
7	185	86	83	85	900	295	900	25	596	117
8	185	86	83	85	900	295	900	25	596	117
9	185	86	83	85	900	295	900	25	596	117
10	185	86	83	85	900	295	900	25	596	117
11	185	86	83	85	900	295	900	25	596	117
12	185	86	83	85	900	295	900	25	596	117
13	185	86	83	85	900	295	900	25	596	117
14	185	86	83	85	900	295	900	25	596	117
15	185	86	83	85	900	295	900	25	596	117
16	185	86	83	85	900	295	900	25	596	117
17	185	86	83	85	900	295	900	25	596	117
18	185	86	83	85	900	295	900	25	596	117
19	185	86	83	85	900	295	900	25	596	117
20	185	86	83	85	900	295	900	25	596	117
21	185	86	83	85	900	295	900	25	596	117
22	185	86	83	85	900	295	900	25	596	117
23	185	86	83	85	900	295	900	25	596	117
24	185	86	83	85	900	295	900	25	596	117
25	185	86	83	85	900	295	900	25	596	117
26	185	86	83	85	900	295	900	25	596	117
27	185	86	83	85	900	295	900	25	596	117
28	185	86	83	85	900	295	900	25	596	117

Cash Inflows (Con't)

Year	41	42	43	44	45	46	47
1	804	4788.5	500	547.9	84	41.4	485.7
2	804	6226.7	10030	604.5	84	41.4	485.7
3	804	3987.8	20660	828.1	84	41.4	485.7
4	804	1067.7	60660	828.1	84	41.4	485.7
5	804	1067.7	60660	828.1	84	41.4	485.7
6	804	1067.7	60660	828.1	84	41.4	485.7
7	804	1067.7	60660	828.1	84	41.4	485.7
8	804	1067.7	60660	828.1	84	41.4	485.7
9	804	00	60660	828.1	84	41.4	485.7
10	804	00	60660	828.1	00	41.4	00
11	804	00	60660	828.1	00	41.4	00
12	804	00	60660	828.1	00	41.4	00
13	804	00	60660	828.1	00	41.4	00
14	804	00	60660	828.1	00	41.4	00
15	804	00	60660	828.1	00	41.4	00
16	804	00	60660	828.1	00	41.4	00
17	804	00	60660	828.1	00	41.4	00
18	00	00	60660	828.1	00	41.4	00
19	00	00	60660	828.1	00	41.4	00
20	00	00	60660	828.1	00	41.4	00
21	00	00	60660	828.1	00	41.4	00
22	00	00	60660	828.1	00	41.4	00
23	00	00	60660	828.1	00	41.4	00
24	00	00	60660	828.1	00	41.4	00
25	00	00	60660	828.1	00	41.4	00
26	00	00	60660	828.1	00	41.4	00
27	00	00	60660	828.1	00	41.4	00
28	00	00	60660	828.1	00	41.4	00

APPENDIX C

DPPO'S DATA BASE

This appendix contains the results from the DPPO
Base case.

RUN NUMBER: DPPO BASE CASE

DEVIATION LEVELS:

COST : 1
SAVINGS : 1 1 1
MANPOWER : 1
CASH FLOWS : 1 1 1

PROJECT NUMBER: 1

INPUT VARIABLES:

TOTAL COST : 572.5
TOTAL SAVINGS : 25445
MANPOWER SAVED : 9
CASH FLOWS : 3585 5465 5465 5465 5465

LAPLACE VALUES FOR ROI IRR AND MPS
4.9384 6.626 1.7467

PROJECT NUMBER: 2

INPUT VARIABLES:

TOTAL COST : 21178
TOTAL SAVINGS : 1.548E5
MANPOWER SAVED : 472
CASH FLOWS : 19350 19350 19350 19350 19350 19350

LAPLACE VALUES FOR ROI IRR AND MPS
0.81215 0.9 2.4763

```
PROJECT NUMBER:3  
INPUT VARIABLES:  
TOTAL COST :5542.2  
TOTAL SAVINGS :1.3007E5  
MANPOWER SAVED:272  
CASH FLOWS :0 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9  
5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9  
LAPLACE VALUES FOR ROI IRR AND MPS  
2.6077 0.587 5.4531
```

```

PROJECT NUMBER:4

INPUT VARIABLES:
TOTAL COST      :268
TOTAL SAVINGS   :6151
MANPOWER SAVED:4
CASH FLOWS      :957 1044.5 1322.5 1413.5 1413.5

LAPLACE VALUES FOR ROI IRR AND MPS
2.3502 3.654 1.6584

```

```
PROJECT NUMBER:5  
  
INPUT VARIABLES:  
TOTAL COST      :629.9  
TOTAL SAVINGS   :16255  
MANPOWER SAVED:0  
CASH FLOWS      :0 650.2 650.2 650.2 650.2 650.2 650.2 650.2  
                  650.2 650.2 650.2 650.2 650.2 650.2 650.2  
                  50.2 650.2  
  
LAPLACE VALUES PCR ROI IRR AND MPS  
2.8673 0.628 0
```

```
PROJECT NUMBER:6  
  
INPUT VARIABLES:  
TOTAL COST      :1033.8  
TOTAL SAVINGS   :5016.7  
MANPOWER SAVED :52.6  
CASH FLOWS     :716.7 716.7 716.7 716.7 716.7 716.7 716.5  
  
LAPLACE VALUES FOR ROI IRR AND MPS  
0.:53919 0.676 5.8534
```

[illegible]

```

PROJECT NUMBER:8

INPUT VARIABLES:
TOTAL COST          :1026.4
TOTAL SAVINGS      :28293
MANPOWER SAVED:0
CASH FLOWS
1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7
31.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7

LAPLACE VALUES FCR ROI IRR AND MPS
3.0628 1.092 0

```

DPPO Base Case (Con't)

PROJECT NUMBER:9

INPUT VARIABLES: :1711.7
TOTAL COST :27530
TOTAL SAVINGS :0
MANPOWER SAVED:115.8 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2
CASH FLOWS :1390.2 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2
90.2

LAPLACE VALUES FCR ROI IRR AND MPS
1.787 0.737 0

PROJECT NUMBER:10

INPUT VARIABLES: :468.8
TOTAL COST :2531
TOTAL SAVINGS :38.9
MANPOWER SAVED:506.2 506.2 506.2 506.2 506.2 506.2
CASH FLOWS :506.2 506.2 506.2 506.2 506.2 506.2
LAPLACE VALUES FCR ROI IRR AND MPS
0.59988 1.039 9.2198

PROJECT NUMBER:11

INPUT VARIABLES: :14345
TOTAL COST :2.5337E5
TOTAL SAVINGS :573
MANPOWER SAVED:33912 31352 31352 31352 31352 31352 31352 31352
CASH FLOWS :33912 31352 31352 31352 31352 31352 31352 31352
LAPLACE VALUES FCR ROI IRR AND MPS
1.9625 2.287 4.4382

```

PROJECT NUMBER:12
INPUT VARIABLES:
TOTAL COSTS:1894
TOTAL SAVINGS:37600
MANPOWER SAVED:0
CASH FLOWS:3760 3760 3760 3760 3760 3760 3760 3760
LAPLACE VALUES PCR ROI IRR AND MPS
2.2058 1.966 0
PROJECT NUMBER:13
INPUT VARIABLES:
TOTAL COSTS:788.5
TOTAL SAVINGS:9198
MANPOWER SAVED:7
CASH FLOWS:459.9 459.9 459.9 459.9 459.9 459.9 459.9 459.9
LAPLACE VALUES PCR ROI IRR AND MPS
1.2961 0.578 0.9864
PROJECT NUMBER:14
INPUT VARIABLES:
TOTAL COSTS:240
TOTAL SAVINGS:3828
MANPOWER SAVED:3
CASH FLOWS:191.4 191.4 191.4 191.4 191.4 191.4 191.4 191.4
LAPLACE VALUES PCR ROI IRR AND MPS
1.7722 0.79 1.3889

```

DPPO Base Case (Con't)

PROJECT NUMBER:15

INPUT VARIABLES:
TOTAL COST :2020
TOTAL SAVINGS :65214
MANPOWER SAVED:14.5
CASH FLOWS :9316.3 9316.3 9316.3 9316.3 9316.3 9316.3 9316.3
LAPLACE VALUES FOR ROI IRR AND MPS
3.5877 4.567 0.79758

PROJECT NUMBER:16

INPUT VARIABLES:
TOTAL COST :147.7
TOTAL SAVINGS :1499
MANPOWER SAVED:5
CASH FLOWS :149.9 149.9 149.9 149.9 149.9 149.9 149.9 149.9 149.9
LAPLACE VALUES FOR ROI IRR AND MPS
1.1277 1.004 3.7614

PROJECT NUMBER:17

INPUT VARIABLES:
TOTAL COST :138.7
TOTAL SAVINGS :1873.5
MANPOWER SAVED:0
CASH FLOWS :143.5 219.5 217.5 215.5 215.5 215.5 215.5 215.5 215.5
LAPLACE VALUES FOR ROI IRR AND MPS
1.5008 1.26 0

DPPO Base Case (Con't)

PROJECT NUMBER: 18

INPUT VARIABLES:

TOTAL COSTS : 126
 TOTAL SAVINGS : 1757.2
 MANPOWER SAVED: 0.6
 CASH FLOWS : 89.2 208.5 208.5 208.5 208.5 208.5 208.5 208.5 208.5

LAPLACE VALUES FOR ROI IRR AND MPS
 1.5496 1.138 0.5291

PROJECT NUMBER: 19

INPUT VARIABLES:

TOTAL COST : 245.2
 TOTAL SAVINGS : 1314.4
 MANPOWER SAVED: 5
 CASH FLOWS : 150.7 129.3 129.3 129.3 129.3 129.3 129.3 129.3 129.3

LAPLACE VALUES FOR ROI IRR AND MPS
 0.59561 0.546 2.2657

PROJECT NUMBER: 20

INPUT VARIABLES:

TOTAL COSTS : 1871.7
 TOTAL SAVINGS : 52637
 MANPOWER SAVED: 0
 CASH FLOWS : 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9
 79.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9

LAPLACE VALUES FOR ROI IRR AND MPS
 3.1247 0.995 0

DPP0 Base Case (Con't)

PROJECT NUMBER:21

INPUT VARIABLES:
TOTAL COST :535.3
TOTAL SAVINGS :5863
MANPOWER SAVED:0
CASH FLOWS :586.3 586.3 586.3 586.3 586.3 586.3 586.3 586.3
LAPLACE VALUES PCR ROI IRR AND MPS
1.217 1.084 0

PROJECT NUMBER:22

INPUT VARIABLES:
TOTAL COST :476.2
TOTAL SAVINGS :5301.1
MANPOWER SAVED:0
CASH FLOWS :764.5 756.1 756.1 756.1 756.1 756.1 756.1 756.1
LAPLACE VALUES PCR ROI IRR AND MPS
1.2369 1.581 0

PROJECT NUMBER:23

INPUT VARIABLES:
TOTAL COST :161.6
TOTAL SAVINGS :1774.5
MANPOWER SAVED:12
CASH FLOWS :354.9 354.9 354.9 354.9 354.9 354.9
LAPLACE VALUES PCR ROI IRR AND MPS
1.2201 2.168 8.2508

```

PROJECT NUMBER:24

INPUT VARIABLES:
TOTAL COST          :135
TOTAL SAVINGS      :10558
MANPOWER SAVED:0
CASH FLOWS
2 3 422.3 422.3 422.3
.3 422.3 422.3

LAPLACE VALUES FOR ROI IRR AND MPS
8.6893 3.098 0

```

```

PROJECT NUMBER:25
INPUT VARIABLES:
TOTAL COSTS:290
TOTAL SAVINGS:1421
MANPOWER SAVED:16
CASH FLOWS:209 202 202 202 202 202 202 202
LAPLACE VALUES FOR ROI, IRR AND MPS
0.54444 0.682 6.1303

```

```
PROJECT NUMBER:26  
INPUT VARIABLES:  
TOTAL COST          :420  
TOTAL SAVINGS       :8763  
HANDPOWER SAVED:0  
CASH FLOWS         :876.3 876.3 876.3 876.3 876.3 876.3 876.3 876.3  
  
LAPLACE VALUES FOR ROI IRR AND MPS  
2.3183 2.066 0
```

PROJECT NUMBER: 27

INPUT VARIABLES:	: 1351.8
TOTAL COSTS	: 14999
TOTAL SAVINGS	: 72
MANPOWER SAVED	: 2249.9
CASH FLOWS	: 2999.8
	: 2999.8
	: 2999.8
	: 3749.8

LAPLACE VALUES	PCR	ROI	IRR	AND	MPS
1.2329	1.836	5.918			

PROJECT NUMBER: 28

[illegible]

LAPLACE VALUES FOR ROI IRR AND MPS

PROJECT NUMBER: 29

```

INPUT VARIABLES:
TOTAL COST      :363.9
TOTAL SAVINGS   :2647.7
MANPOWER SAVED :11.4
CASH FLOWS      :125.9
                280.2 280.2 280.2 280.2 280.2 280.2 280.2
LAPLACE VALUES FOR ROI IRR AND MPS
0.80843 0.599

```

DPPO Base Case (Con't)

PROJECT NUMBER:30

INPUT VARIABLES: :370

TOTAL COST :3439.7

TOTAL SAVINGS :7.6

HANPOWER SAVED:356.5

CASH FLOWS :367.4 389.3 412.8 437.5 463.7 491.5 521

LAPLACE VALUES FOR ROI IRR AND MPS

1.0329 0.994 2.2823

PROJECT NUMBER:31

INPUT VARIABLES: :177

TOTAL COST :1480

TOTAL SAVINGS :3

HANPOWER SAVED:185

CASH FLOWS :185 185 185 185 185 185 185

LAPLACE VALUES FOR ROI IRR AND MPS

0.92906 1.032 1.8832

PROJECT NUMBER:32

INPUT VARIABLES: :173.1

TOTAL COST :1897

TOTAL SAVINGS :1.8

HANPOWER SAVED:86.2

CASH FLOWS :86.2 86.2 86.2 86.2 86.2 86.2 86.2

LAPLACE VALUES FOR ROI IRR AND MPS

1.21477 0.473 1.1554

DDPO Base Case (Con't)

PROJECT NUMBER:33

INPUT VARIABLES:
TOTAL COST :861.3
TOTAL SAVINGS :836.6
MANPOWER SAVED:13.7
CASH FLOWS :836.6 836.6 836.6 836.6 836.6 836.6 836.6 836.6 836.6 836.6

LAPLACE VALUES FOR ROI IRR AND MPS
1.0792 0.961 1.7674

PROJECT NUMBER:34

INPUT VARIABLES:
TOTAL COST :520
TOTAL SAVINGS :12789
MANPOWER SAVED:1.5
CASH FLOWS :852.6 852.6 852.6 852.6 852.6 852.6 852.6 852.6 852.6 852.6

LAPLACE VALUES FOR ROI IRR AND MPS
2.4327 1.624 0.32051

PROJECT NUMBER:35

INPUT VARIABLES:
TOTAL COST :908
TOTAL SAVINGS :7200
MANPOWER SAVED:6
CASH FLOWS :900 900 900 900 900 900 900 900 900 900

LAPLACE VALUES FOR ROI IRR AND MPS
0.88106 0.978 0.73421

DEPO Base Case (Con't)

PROJECT NUMBER:36

INPUT VARIABLES:
TOTAL COST :298.7
TOTAL SAVINGS :2361.6
MANPOWER SAVED:18
CASH FLOWS :295.2 295.2 295.2 295.2 295.2 295.2 295.2

LAPLACE VALUES FOR ROI IRR AND MPS
0.87847 0.975 6.6957

PROJECT NUMBER:37

INPUT VARIABLES:
TOTAL COST :935
TOTAL SAVINGS :6700
MANPOWER SAVED:44.4
CASH FLOWS :400 900 900 900 900 900 900 900

LAPLACE VALUES FOR ROI IRR AND MPS
0.7962 0.72 5.2763

PROJECT NUMBER:38

INPUT VARIABLES:
TOTAL COST :199
TOTAL SAVINGS :2460
MANPOWER SAVED:2
CASH FLOWS :225 235 250 250 250 250 250 250

LAPLACE VALUES FOR ROI IRR AND MPS
1.3735 1.158 1.1167

DPPO Base Case (Con't)

PROJECT NUMBER:39

INPUT VARIABLES:
TOTAL COST :635
TOTAL SAVINGS :4768
MANPOWER SAVED:15
CASH FLOWS :596 596 596 596 596 596 596

LAPLACE VALUES FOR ROI IRR AND MPS
0.8343 0.925 2.6247

PROJECT NUMBER:40

INPUT VARIABLES:
TOTAL COST :143.3
TOTAL SAVINGS :940.8
MANPOWER SAVED:3.3
CASH FLOWS :117.6 117.6 117.6 117.6 117.6 117.6 117.6

LAPLACE VALUES FOR ROI IRR AND MPS
0.72947 0.806 2.5587

PROJECT NUMBER:41

INPUT VARIABLES:
TOTAL COST :262
TOTAL SAVINGS :12060
MANPOWER SAVED:0.3
CASH FLOWS :804 804 804 804 804 804 804 804 804 804

LAPLACE VALUES FOR ROI IRR AND MPS
5.1145 3.039 0.12723

DPP0 Base Case (Con't)

PROJECT NUMBER:42

INPUT VARIABLES:

TOTAL COST :5931.5
TOTAL SAVINGS :23261
HANPOWER SAVED:651.2
CASH FLOWS :4788.5 6226 3987.7 3987.8 1067.7 1067.7 1067.7 1067.7

LAPLACE VALUES FOR ROI IRR AND MPS
0.43573 0.763 12.199

PROJECT NUMBER:43

INPUT VARIABLES:

TOTAL COST :3182
TOTAL SAVINGS :45950
HANPOWER SAVED:4
CASH FLOWS :500 1000 2030 6060 6060 6060 6060 6060 6060

LAPLACE VALUES FOR ROI IRR AND MPS
1.6045 0.641 0.13967

PROJECT NUMBER:44

INPUT VARIABLES:

TOTAL COST :870
TOTAL SAVINGS :9427.4
HANPOWER SAVED:13.6
CASH FLOWS :541.9 604.5 828.1 828.1 828.1 828.1 828.1 828.1 828.1 82

LAPLACE VALUES FOR ROI IRR AND MPS
1.204 0.741 1.7369

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PROJECT NUMBER: 45

INPUT VARIABLES:

TOTAL COST :121

TOTAL SAVINGS :672

HANPOWER SAVED: 2

CASH FLOWS: \$4 84 84 84 84 84 84
SMTI HSTC

LAPLACE VALUES FCR ROI IRR AND MPS

1.8365

PROJECT NUMBER: 46

INPUT VARIABLES:

TOTAL COST : 105.8

TOTAL SAVINGS	:828
TOTAL SAVINGS	:828

HANPOWER SAVED: 2.5

CASH FLOWS : 41.4 41.4 41.4 41.4 41.4 41.4 41.4 41.4 41.4 41.4

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LAPLACE VALUES FOR ROI IRR AND MPS

10% 2.6255

PROJECT NUMBER: 47

INPUT VARIABLES:

TOTAL COST :294.9

TOTAL SAVINGS: \$485,584

MANPOWER SAVED: 2

CASH FLOWS :485.7 485.7 485.7 485.7 485.7 485.7 485.7 485.7

LAPLACE VALUES FCR ROI IRR AND MPS

1.631 0.75355

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DPP0 Base Case (Con't)

NO	ROI	I RR	MPS
1	44.445	6.626	15.721
2	7.309	0.900	22.287
3	23.469	0.587	49.078
4	22.951	3.654	14.925
5	25.806	0.628	0.000
6	4.852	0.676	50.880
7	25.590	1.014	0.000
8	27.565	1.092	0.000
9	16.083	0.737	0.000
10	5.398	1.039	82.978
11	17.663	2.287	39.944
12	19.852	1.966	0.000
13	11.665	0.578	8.877
14	15.950	0.790	12.500
15	32.284	4.567	7.178
16	10.149	1.004	33.852
17	13.508	1.260	0.000
18	13.946	1.138	4.761
19	5.360	0.546	20.392
20	28.123	0.995	0.000
21	10.953	1.084	0.000
22	11.132	1.581	0.000
23	10.981	2.168	74.257
24	78.204	3.098	0.000
25	4.900	0.682	25.172
26	20.864	2.066	0.000
27	11.096	1.836	53.262
28	35.192	1.394	0.000
29	7.275	0.599	31.327
30	9.296	0.994	20.541
31	8.361	1.032	16.949
32	10.959	0.473	10.399
33	9.713	0.961	15.906
34	24.594	1.624	2.884
35	7.929	0.978	6.607
36	7.906	0.975	60.261
37	7.166	0.720	47.487
38	12.362	1.158	10.050
39	7.509	0.925	23.622
40	6.565	0.806	23.029
41	46.031	3.039	1.145
42	3.922	0.763	109.790
43	14.441	0.641	1.257
44	10.836	0.741	15.632
45	5.554	0.677	16.529
46	7.826	0.387	23.629
47	16.470	1.631	6.782

DPFO Base Case (Con't)

THE FINAL RANKING:

NO	RANK
1	1
2	31
3	12
4	5
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6	39
7	22
8	16
9	42
10	16.5
11	2
12	15
13	43
14	25
15	3.5
16	14
17	26
18	20
19	47
20	21
21	36
22	27
23	3.5
24	8
25	34.5
26	13
27	6
28	11
29	40.5
30	24
31	23
32	45
33	28.5
34	9
35	36
36	18
37	32
38	16.5
39	28.5
40	34.5
41	7
42	30
43	40.5
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APPENDIX D

UNCERTAINTY BASE CASE

This appendix contains the results of the initial runs used to determine the impact of uncertainty on DPPO's current procedures.

RUN NUMBER: UNCERTAINTY BASE CASE

DEVIATION LEVELS:
 COST : 1.256 1 0.825
 SAVINGS : 1.014 1 0.3316
 MANPOWER : 1.1 1 0.9
 CASH FLOWS : 1.014 1 0.3316

PROJECT NUMBER: 1

INPUT VARIABLES:
 TOTAL COST : 572.5
 TOTAL SAVINGS : 25445
 MANPOWER SAVED: 9
 CASH FLOWS : 3585 5465 5465 5465 5465

LAPLACE VALUES FOR ROI IRR AND MPS
 34.847 5.2363 15.764

PROJECT NUMBER: 2

INPUT VARIABLES:
 TOTAL COST : 21178
 TOTAL SAVINGS : 1.548E5
 MANPOWER SAVED: 472
 CASH FLOWS : 19350 19350 19350 19350 19350 19350

LAPLACE VALUES FOR ROI IRR AND MPS
 5.7307 0.68767 22.349

PROJECT NUMBER:3									
INPUT VARIABLES:									
TOTAL COSTS: 5542.2									
TOTAL SAVINGS: 13007E5									
MANPOWER SAVED: 272									
CASH FLOWS									
5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9 5202.9									
LAPLACE VALUES FOR ROI IRR AND MPS									
18.401 0.47567 49.214									
PROJECT NUMBER:4									
INPUT VARIABLES:									
TOTAL COSTS: 268									
TOTAL SAVINGS: 6151									
MANPOWER SAVED: 4									
CASH FLOWS: 957 1044.5 1322.5 1413.5 1413.5									
LAPLACE VALUES FOR ROI IRR AND MPS									
17.995 2.8747 14.967									
PROJECT NUMBER:5									
INPUT VARIABLES:									
TOTAL COSTS: 629.9									
TOTAL SAVINGS: 16255									
MANPOWER SAVED: 0									
CASH FLOWS: 0 650.2 650.2 650.2 650.2 650.2 650.2 650.2 650.2 650.2									
50.2 650.2									
LAPLACE VALUES FOR ROI IRR AND MPS									
20.232 0.51 0									

PROJECT NUMBER: 6

INPUT VARIABLES:	
TOTAL COST	: 1033.8
TOTAL SAVINGS	: 5016.7
HANDPOWER SAVED	: 52.6
CASH FLOWS	: 716.7

HANPOPER SAVED:52.6
CASH FLOWS:716.7 716.7 716.7 716.7 716.7 716.7 716.7 716.5

LAPLACE VALUES FOR ROI IRR AND MPS
3.8046 0.50633 51.021

PROJECT NUMBER: 7

```

INPUT VARIABLES:
TOTAL COST          : 784.2
TOTAL SAVINGS       : 20068
MANPOWER SAVED     : 0
CASH FLOWS          : 802.7
CASH FLOWS          : 802.7
CASH FLOWS          : 802.7

```

CASH FLOWS

LAPLACE	VALUES	FCR	ROI	IRR	AND	MPS
20.063	0.79267	0				

PROJECT NUMBER: 8

INPUT VARIABLES:	1026.4
TOTAL COSTS	:28293
TOTAL SAVINGS	:0
MANPOWER SAVED	:1131.7
CASH FLOWS	1131.7
	31.7
	1131.7
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MANPOWER SAVED:0
CASH FLOWS :1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7
31.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7 1131.7

LAPLACE	VALUES	FCR	ROI	IRR	AND	MPS
21.612	0.85367	0				

```

PROJECT NUMBER:9

INPUT VARIABLES:
TOTAL COSTS      :1711.7
TOTAL SAVINGS    :27530
MANPOWER SAVED:0
CASH FLOWS      :1115.8 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2
                  1390.2 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2 1390.2
                  90.2

LAPLACE VALUES FOR ROI IRR AND MPS
12.61
0.57933 0

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PROJECT NUMBER:10

INPUT VARIABLES:
TOTAL COST      :468.8
TOTAL SAVINGS   :2531
HANNPOWER SAVED:38.9
CASH FLOWS      :506.2 506.2 506.2 506.2 506.2

LAPLACE VALUES PCR ROI IRR AND MPS
4.2329 0.774 83.207

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PROJECT NUMBER:11

INPUT VARIABLES:
TOTAL COST          :14345
TOTAL SAVINGS      :2.5337E5
MANPOWER SAVED     :573
CASH FLOWS         :33912 31352 31352 31352 31352 31352 31352 31352

LAPLACE VALUES FOR ROI IRR AND MPS
13.848      1.7803 40.055

```

Uncertainty Base Case (Con't)

PROJECT NUMBER:12

INPUT VARIABLES:

TOTAL COST :1894

TOTAL SAVINGS :37600

HANPOWER SAVED:0

CASH FLOWS :3760 3760 3760 3760 3760 3760 3760 3760 3760

LAPLACE VALUES FOR ROI IRR AND MPS

15.565 1.536 0

PROJECT NUMBER:13

INPUT VARIABLES:

TOTAL COST :788.5

TOTAL SAVINGS :9198

HANPOWER SAVED:7

CASH FLOWS :459.9 459.9 459.9 459.9 459.9 459.9 459.9 459.9 459.9

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LAPLACE VALUES FOR ROI IRR AND MPS

9.1459 0.45 8.9022

PROJECT NUMBER:14

INPUT VARIABLES:

TOTAL COST :240

TOTAL SAVINGS :3828

HANPOWER SAVED:3

CASH FLOWS :191.4 191.4 191.4 191.4 191.4 191.4 191.4 191.4 191.4

1.4 191.4 191.4 191.4 191.4 191.4 191.4 191.4 191.4

LAPLACE VALUES FOR ROI IRR AND MPS

12.505 0.617 12.535

Uncertainty Base Case (Con't)

PROJECT NUMBER:15

INPUT VARIABLES: :2020
TOTAL COST :65214
TOTAL SAVINGS :14.5
HANPOWER SAVED :9316.3 9316.3 9316.3 9316.3 9316.3 9316.3
CASH FLOWS :9316.3 9316.3 9316.3 9316.3 9316.3 9316.3
LAPLACE VALUES FCR ROI IRR AND MPS
25.312 3.57 7.1981

PROJECT NUMBER:16

INPUT VARIABLES: :147.7
TOTAL COST :1499
TOTAL SAVINGS :5
HANPOWER SAVED :149.9 149.9 149.9 149.9 149.9 149.9 149.9 149.9
CASH FLOWS :149.9 149.9 149.9 149.9 149.9 149.9 149.9 149.9
LAPLACE VALUES FCR ROI IRR AND MPS
7.9571 0.778 33.946

PROJECT NUMBER:17

INPUT VARIABLES: :138.7
TOTAL COST :1873.5
TOTAL SAVINGS :0
HANPOWER SAVED :143.5 219.5 217.5 215.5 215.5 215.5 215.5 215.5
CASH FLOWS :143.5 219.5 217.5 215.5 215.5 215.5 215.5 215.5
LAPLACE VALUES FCR ROI IRR AND MPS
10.59 0.99267 0

Uncertainty Base Case (Con't)

PROJECT NUMBER:18

INPUT VARIABLES: :126
TOTAL COST :1757.2
TOTAL SAVINGS :0.6
MANPOWER SAVED:89.2 208.5 208.5 208.5 208.5 208.5 208.5 208.5 208.5

LAPLACE VALUES FOR ROI, IRR AND MPS
10.934 0.906 4.7751

PROJECT NUMBER:19

INPUT VARIABLES: :245.2
TOTAL COST :1314.4
TOTAL SAVINGS :5
MANPOWER SAVED:150.7 129.3 129.3 129.3 129.3 129.3 129.3 129.3 129.3

LAPLACE VALUES FOR ROI, IRR AND MPS
4.2028 0.40733 20.448

PROJECT NUMBER:20

INPUT VARIABLES: :1871.7
TOTAL COST :52637
TOTAL SAVINGS :0
MANPOWER SAVED:1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9
CASH FLOWS :1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9
79.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9 1879.9

LAPLACE VALUES FOR ROI, IRR AND MPS
22.049 0.778 0

Uncertainty Base Case (Con't)

PROJECT NUMBER:21

INPUT VARIABLES: :535.3

TOTAL COST :5863

TOTAL SAVINGS :0

HANPOWER SAVED:0

CASH FLOWS :586.3 586.3 586.3 586.3 586.3 586.3 586.3 586.3 586.3 586.3

LAPLACE VALUES FOR ROI IRR AND MPS
8.5873 0.84133 0

PROJECT NUMBER:22

INPUT VARIABLES: :476.2

TOTAL COST :5301.1

TOTAL SAVINGS :0

HANPOWER SAVED:0

CASH FLOWS :764.5 756.1 756.1 756.1 756.1 756.1 756.1 756.1 756.1 756.1

LAPLACE VALUES FOR ROI IRR AND MPS
8.7279 1.2257 0

PROJECT NUMBER:23

INPUT VARIABLES: :161.6

TOTAL COST :1774.5

TOTAL SAVINGS :12

HANPOWER SAVED:0

CASH FLOWS :354.9 354.9 354.9 354.9 354.9 354.9 354.9 354.9 354.9 354.9

LAPLACE VALUES FOR ROI IRR AND MPS
8.6093 1.6773 74.463

Uncertainty Base Case (Con't)

PROJECT NUMBER: 24

```

INPUT VARIABLES: = 135
TOTAL COSTS: = 10558
TOTAL SAVINGS: = 0
MANPOWER SAVED: = 422.3
CASH FLOWS: = 2.3 422.3 422.3 422.3

```

LAPLACE VALUES PCR ROI YRR AND MPS
61.314 2.4223 0

PROJECT NUMBER: 25

[illegible]

LAPLACE VALUES	PCR	ROI	IRR	AND MPS
3.8417	0.50333	55.325		

PROJECT NUMBER: 26

[illegible]

Uncertainty Base Case (Con't)

PROJECT NUMBER:27

INPUT VARIABLES: :1351.8
 TOTAL COST :14999
 TOTAL SAVINGS :72
 MANPOWER SAVED:2249.9 2999.8 2999.8 2999.8 3749.8
 CASH FLOWS :2249.9 2999.8 2999.8 2999.8 3749.8
 LAPLACE VALUES FOR ROI IRR AND MPS
 8.6993 1.4327 53.41

PROJECT NUMBER:28

INPUT VARIABLES: :616.9
 TOTAL COST :21710
 TOTAL SAVINGS :0
 MANPOWER SAVED:868.4 868.4 868.4 868.4 868.4 868.4 868.4 868.4 868.4 868.4
 CASH FLOWS :868.4 868.4 868.4 868.4 868.4 868.4 868.4 868.4 868.4 868.4
 .4 868.4 868.4

LAPLACE VALUES FOR ROI IRR AND MPS
 27.592 1.0963 0

PROJECT NUMBER:29

INPUT VARIABLES: :363.9
 TOTAL COST :2647.7
 TOTAL SAVINGS :11.4
 MANPOWER SAVED:125.9 280.2 280.2 280.2 280.2 280.2 280.2 280.2 280.2 280.2
 CASH FLOWS :125.9 280.2 280.2 280.2 280.2 280.2 280.2 280.2 280.2 280.2
 LAPLACE VALUES FOR ROI IRR AND MPS
 5.7045 0.46333 31.414

Uncertainty Base Case (Con't)

PROJECT NUMBER:30

INPUT VARIABLES: :370
TOTAL COST :3439.7
TOTAL SAVINGS :7.6
HANPOWER SAVED: :356.5 367.4 389.3 412.8 437.5 463.7 491.5 521
CASH FLOWS
LAPLACE VALUES FOR ROI IRR AND MPS
7.2887 0.77233 20.597

PROJECT NUMBER:31

INPUT VARIABLES: :177
TOTAL COST :1480
TOTAL SAVINGS :3
HANPOWER SAVED: :185 185 185 185 185 185 185 185
CASH FLOWS
LAPLACE VALUES FOR ROI IRR AND MPS
6.5557 0.79333 16.996

PROJECT NUMBER:32

INPUT VARIABLES: :173.1
TOTAL COST :1897
TOTAL SAVINGS :1.8
HANPOWER SAVED: :86.2 86.2 86.2 86.2 86.2 86.2 86.2 86.2
CASH FLOWS
86.2 86.2 86.2 86.2 86.2 86.2 86.2 86.2
LAPLACE VALUES FOR ROI IRR AND MPS
8.5922 0.36333 10.427

Uncertainty Base Case (Con't)

PROJECT NUMBER:33

INPUT VARIABLES: :861.3
TOTAL COST :8366
TOTAL SAVINGS :13.7
MANPOWER SAVED:836.6
CASH FLOWS :836.6 836.6 836.6 836.6 836.6 836.6 836.6

LAPLACE VALUES FOR ROI IRR AND MPS
7.6155 0.74567 15.95

PROJECT NUMBER:34

INPUT VARIABLES: :520
TOTAL COST :12789
TOTAL SAVINGS :1.5
MANPOWER SAVED:852.6
CASH FLOWS :852.6 852.6 852.6 852.6 852.6 852.6 852.6

LAPLACE VALUES FOR ROI IRR AND MPS
19.283 1.2697 2.8926

PROJECT NUMBER:35

INPUT VARIABLES: :908
TOTAL COST :7200
TOTAL SAVINGS :6
MANPOWER SAVED:900
CASH FLOWS :900 900 900 900 900 900 900

LAPLACE VALUES FOR ROI IRR AND MPS
6.217 0.75033 6.6262

AD-A140 864

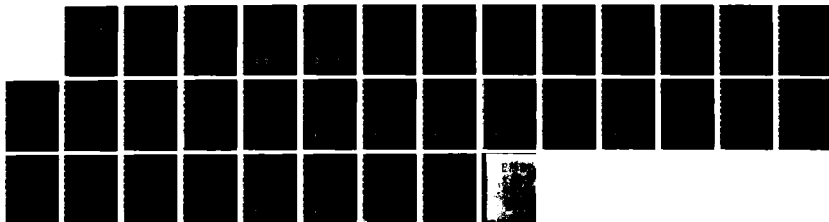
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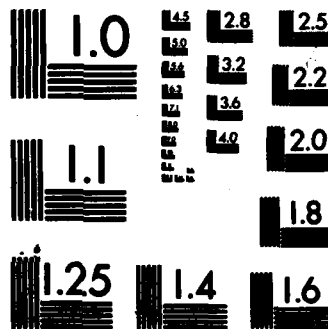
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Uncertainty Base Case (Con't)

PROJECT NUMBER:36

INPUT VARIABLES: :298.7
 TOTAL COST :2361.6
 TOTAL SAVINGS :295.2 295.2 295.2 295.2 295.2 295.2 295.2
 HANPOWER SAVED:18
 CASH FLOWS :295.2 295.2 295.2 295.2 295.2 295.2 295.2

LAPLACE VALUES FOR ROI, IRR AND MPS
 6.1987 0.748 60.428

PROJECT NUMBER:37

INPUT VARIABLES: :935
 TOTAL COST :6700
 TOTAL SAVINGS :400 900 900 900 900 900 900
 HANPOWER SAVED:44.4
 CASH FLOWS :400 900 900 900 900 900 900

LAPLACE VALUES FOR ROI, IRR AND MPS
 5.6182 0.55633 47.618

PROJECT NUMBER:38

INPUT VARIABLES: :199
 TOTAL COST :2460
 TOTAL SAVINGS :225 235 250 250 250 250 250
 HANPOWER SAVED:2
 CASH FLOWS :225 235 250 250 250 250 250

LAPLACE VALUES FOR ROI, IRR AND MPS
 9.692 0.904 10.078

Uncertainty Base Case (Con't)

PROJECT NUMBER:39

INPUT VARIABLES:

TOTAL COST :635

TOTAL SAVINGS :4768

HANPOWER SAVED:15

CASH FLOWS :596 596 596 596 596 596 596 596

LAPLACE VALUES FOR ROI IRR AND NPS

5.887 0.70767 23.687

PROJECT NUMBER:40

INPUT VARIABLES:

TOTAL COST :143.3

TOTAL SAVINGS :940.8

HANPOWER SAVED:3.3

CASH FLOWS :117.6 117.6 117.6 117.6 117.6 117.6 117.6 117.6

LAPLACE VALUES FOR ROI IRR AND NPS

5.1473 0.61167 23.092

PROJECT NUMBER:41

INPUT VARIABLES:

TOTAL COST :262

TOTAL SAVINGS :12060

HANPOWER SAVED:0.3

CASH FLOWS :804 804 804 804 804 804 804 804 804 804

LAPLACE VALUES FOR ROI IRR AND NPS

36.089 2.376 1.1482

Uncertainty Base Case (Con't)

PROJECT NUMBER:42

INPUT VARIABLES:
TOTAL COST :5931.5
TOTAL SAVINGS :2326.1
HANDPOWER SAVED:631.2
CASH FLOWS :4700.5

6226 3987.7 3987.8 1067.7 1067.7 1067.7 1067.7

LAPLACE VALUES FOR ROI IRR AND NPS
3.6746 0.544 110.09

PROJECT NUMBER:43

INPUT VARIABLES:
TOTAL COST :3182
TOTAL SAVINGS :45950
HANDPOWER SAVED:4
CASH FLOWS :500

1000 2030 6060 6060 6060 6060 6060 6060

LAPLACE VALUES FOR ROI IRR AND NPS
11.322 0.52933 1.2605

PROJECT NUMBER:44

INPUT VARIABLES:
TOTAL COST :870
TOTAL SAVINGS :9427.4
HANDPOWER SAVED:131.6
CASH FLOWS :541.9

604.5 828.1 828.1 828.1 828.1 828.1 828.1 828.1 828.1 82

LAPLACE VALUES FOR ROI IRR AND NPS
8.4958 0.56269 15.675

Uncertainty Base Case (Con't)

PROJECT NUMBER:45

INPUT VARIABLES:

TOTAL COSTS :121

TOTAL SAVINGS :672

HANPOWER SAVED:2

CASH FLOWS :84 84 84 84 84 84 84 84

LAPLACE VALUES FOR ROI, IRR AND NPS

4.3543 0.507 16.575

PROJECT NUMBER:46

INPUT VARIABLES:

TOTAL COSTS :105.8

TOTAL SAVINGS :828

HANPOWER SAVED:2.5

CASH FLOWS :41.4 41.4 41.4 41.4 41.4 41.4 41.4 41.4 41.4 41.4

LAPLACE VALUES FOR ROI, IRR AND NPS

6.1359 0.298 23.695

PROJECT NUMBER:47

INPUT VARIABLES:

TOTAL COSTS :294.9

TOTAL SAVINGS :4857

HANPOWER SAVED:2

CASH FLOWS :485.7 485.7 485.7 485.7 485.7 485.7 485.7 485.7 485.7 485.7

LAPLACE VALUES FOR ROI, IRR AND NPS

12.913 1.273 6.8007

Uncertainty Base Case (Con't)

NO	MAXHPS	MINHPS	MAXHPS	MINHPS	MAXHPS	MINHPS
1	11.7340	11.7340	6.7114	2.369	20.961	11.265
2	11.9298	11.9298	0.913	0.250	29.716	15.970
3	11.9662	11.9662	0.5933	0.225	65.437	35.167
4	11.9888	11.9888	0.703	0.267	19.900	10.695
5	11.9999	11.9999	0.635	0.267	0.000	0.000
6	11.9999	11.9999	0.686	0.157	67.840	36.459
7	11.9999	11.9999	0.107	0.336	0.000	0.000
8	11.9999	11.9999	0.747	0.258	0.000	0.000
9	11.9999	11.9999	0.055	0.288	0.000	0.000
10	11.9999	11.9999	0.320	0.288	11.000	59.459
11	11.9999	11.9999	0.994	0.648	53.259	28.622
12	11.9999	11.9999	0.586	0.186	0.000	0.000
13	11.9999	11.9999	0.801	0.260	11.837	6.361
14	11.9999	11.9999	0.631	0.512	16.667	8.957
15	11.9999	11.9999	0.199	0.311	9.571	5.143
16	11.9999	11.9999	0.276	0.442	45.137	24.257
17	11.9999	11.9999	0.151	0.429	0.000	0.000
18	11.9999	11.9999	0.555	0.121	6.349	3.412
19	11.9999	11.9999	0.099	0.330	27.189	14.612
20	11.9999	11.9999	0.604	0.481	0.000	0.000
21	11.9999	11.9999	0.199	0.492	0.000	0.000
22	11.9999	11.9999	0.141	0.288	99.010	53.210
23	11.9999	11.9999	0.692	0.136	0.000	0.000
24	11.9999	11.9999	0.860	0.682	73.563	39.534
25	11.9999	11.9999	0.114	0.602	71.016	38.166
26	11.9999	11.9999	0.606	0.185	0.000	0.000
27	11.9999	11.9999	0.086	0.315	41.770	22.448
28	11.9999	11.9999	0.480	0.302	27.387	14.719
29	11.9999	11.9999	0.975	0.137	22.599	12.145
30	11.9999	11.9999	0.480	0.301	13.865	7.451
31	11.9999	11.9999	0.975	0.338	21.208	11.398
32	11.9999	11.9999	0.992	0.281	3.846	2.067
33	11.9999	11.9999	0.992	0.280	8.810	4.735
34	11.9999	11.9999	0.992	0.280	0.348	43.181
35	11.9999	11.9999	0.992	0.280	63.316	34.027
36	11.9999	11.9999	0.992	0.280	13.400	7.201
37	11.9999	11.9999	0.992	0.280	31.496	16.927
38	11.9999	11.9999	0.992	0.280	30.705	16.501
39	11.9999	11.9999	0.992	0.280	1.526	0.820
40	11.9999	11.9999	0.992	0.280	14.380	78.669
41	11.9999	11.9999	0.992	0.280	1.676	0.901
42	11.9999	11.9999	0.992	0.280	20.843	11.201
43	11.9999	11.9999	0.992	0.280	22.039	11.844
44	11.9999	11.9999	0.992	0.280	9.506	4.855

Uncertainty Base Case (Con't)

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAXIMIN	LAPLACE	MAXIMAX
1	1	1	1
2	34	31	31
3	9.5	12	12
4	5	5	5
5	28	34	37
6	42	41	39
7	21	22	22
8	17	18	19
9	38	40	42
10	30	20	16.5
11	2	2	2
12	15	15	15
13	36	43	43
14	23	24.5	25
15	3	3.5	3.5
16	14	14	14
17	25.5	26	26
18	19	19	20
19	47	47	47
20	20	21	21
21	35	36	36
22	28	27	27
23	4	3.5	3.5
24	8	8	8
25	40.5	38.5	34.5
26	13	13	13
27	6	6	6
28	1	1	1
29	33	32	40.5
30	22	23.5	24
31	24	23	23
32	45	45	45
33	25.5	28	28.5
34	9.5	9	9
35	3	3	3
36	18	16.5	18
37	33	31	32
38	16	16	16.5
39	31	28.5	28.5
40	40.5	35	34.5
41	7	7	7
42	3	3	30
43	28	31	40.5
44	3	3	33
45	6	6	46
46	3	3	44
47	11	10	10

APPENDIX E

SENSITIVITY ANALYSIS RESULTS

This appendix contains the different computer runs performed during sensitivity analysis. Descriptions of the runs are noted at the top of each output.

RUN NUMBER: COST LOW - HANPOWER HIGH

DEVIATION LEVELS: 1 0.2 3 16
 COST : 1.256
 SAVINGS : 1.014
 HANPOWER : 2.2
 CASHFLOWS: 1.014 1 0.33 16

NO	HAXROI	HAXIRR	HAXHPS	HAXHPS
1	235:34	7714	172:93	11:265
2	118:35	60:913	145:86	15:169
3	130:36	00:393	234:100	35:000
4	124:60	00:686	40:068	10:000
5	139:75	1:028	59:000	36:000
6	131:54	1:107	00:000	00:000
7	129:57	0:747	00:000	00:000
8	121:53	0:055	00:000	00:000
9	100:65	1:329	12:334	59:000
10	109:14	2:394	43:039	20:000
11	80:66	0:580	97:005	00:000
12	163:68	4:631	137:56	6:361
13				8:143
14				
15				

THE FINAL RANKINGS LISTED BY METHOD:

NO	HAXHIN	LAPLACE	HAXHAI
1	12	10	10
2	3	7	7
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3
7	3	3	3
8	3	3	3
9	3	3	3
10	3	3	3
11	3	3	3
12	3	3	3
13	3	3	3
14	3	3	3
15	3	3	3

RUN NUMBER: COST LOW - MANPOWER LOW

DEVIATION LEVELS: 1 0.2 3 16
 COST : 1.256 1 0.3 3 16
 SAVINGS : 1.014 1 0.3 3 16
 MANPOWER : 1.1 1 0.3 3 16
 CASH FLOWS : 1.014 1 0.3 3 16

NO	MANROI	MINROI	MAXIRR	MINIRR	MAXIRR	MINHRS	MAXHRS	MINHRS
1	225.358	11.734	6.914	2.369	86.466	2.534	2.534	2.534
2	37.096	11.929	0.000	2.247	23.258	3.815	3.815	3.815
3	110.360	16.159	3.000	2.267	23.000	2.300	2.300	2.300
4	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
5	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
6	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
7	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
8	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
9	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
10	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
11	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
12	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
13	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
14	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300
15	110.360	16.013	3.000	2.267	23.000	2.300	2.300	2.300

THE FINAL RANKINGS LISTED BY METHOD:

NO MAXI MIN LAPLACE MAXI MAX

NO	MAXI	MIN	LAPLACE	MAXI	MAX
1	12.5	10.6	10.6	10.6	10.6
2	12.5	10.6	10.6	10.6	10.6
3	12.5	10.6	10.6	10.6	10.6
4	12.5	10.6	10.6	10.6	10.6
5	12.5	10.6	10.6	10.6	10.6
6	12.5	10.6	10.6	10.6	10.6
7	12.5	10.6	10.6	10.6	10.6
8	12.5	10.6	10.6	10.6	10.6
9	12.5	10.6	10.6	10.6	10.6
10	12.5	10.6	10.6	10.6	10.6
11	12.5	10.6	10.6	10.6	10.6
12	12.5	10.6	10.6	10.6	10.6
13	12.5	10.6	10.6	10.6	10.6
14	12.5	10.6	10.6	10.6	10.6
15	12.5	10.6	10.6	10.6	10.6

RUN NUMBER: SAVINGS LOW - MANPOWER HIGH

DEVIATION LEVELS: 1 0.825
 COST : 1.256
 SAVINGS : 1.014
 MANPOWER : 2.214
 CASH FLOWS : 1.014

NO	MAX ROI	MIN ROI	MAX IRR	MIN IRR	MAX MPS	MIN MPS
1	54.627	3.538	6.714	0.074	41.923	11.297
2	8.983	0.586	0.913	0.066	59.487	15.167
3	28.346	1.867	0.593	0.032	130.800	10.695
4	31.718	2.557	0.735	0.082	130.680	36.000
5	31.952	0.383	0.688	0.190	130.000	0.000
6	33.480	2.194	1.027	0.099	0.000	0.000
7	33.768	1.280	1.147	0.047	0.000	0.000
8	33.768	0.409	1.055	0.178	0.000	59.487
9	31.635	1.406	1.230	0.146	21.520	52.052
10	21.700	0.408	1.320	0.014	21.520	0.000
11	24.338	1.592	1.398	0.041	33.631	8.514
12	19.680	1.267	1.586	0.041	19.631	0.365
13	19.680	2.570	0.801	0.041	33.631	0.365
14	19.680	1.267	0.801	0.041	19.631	8.514
15	19.680	2.570	0.801	0.041	19.631	0.365

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAX	MIN	LAPLACE	MAX	MIN	MAX
1	12.5	1	1	10	1	1
2	4.5	10	5.5	7	3.5	5
3	3	5.5	3.5	13	5.5	5
4	8.5	11.5	11.5	11	5.5	5
5	12.5	13	8.5	8	5.5	5
6	6	14	5.5	14	5.5	5
7	15	17	3.5	3	5.5	5
8	11	9	11.5	15	5.5	5
9	14	12	12	11	5.5	5
10	10	14	10.5	12	5.5	5
11	12	10	11.5	13	5.5	5
12	13	11	12.5	14	5.5	5
13	14	12	13.5	15	5.5	5
14	15	13	14.5	16	5.5	5
15	16	14	15.5	17	5.5	5

RUN NUMBER: COST LOW - SAVINGS LOW

DEVIATION LEVELS: 1 0.2
 COST : 1.256
 SAVINGS : 1.014
 HANPOWER : 1.1
 CASHFLOWS: 1.014 1 0.1

NO	MAXROI	MINROI	MAXIRR	MINIRR	MAXHPS	MINHPS
1	225.340	3.539	6.714	0.749	86.468	11.265
2	37.058	0.582	0.913	0.063	122.583	15.370
3	118.360	1.869	0.593	0.073	269.939	35.167
4	130.603	1.827	0.703	0.322	82.000	10.000
5	129.740	2.054	0.686	0.115	279.840	36.459
6	139.542	2.037	1.028	0.090	0.000	0.000
7	181.572	2.195	1.107	0.099	0.000	0.000
8	27.550	1.281	0.747	0.049	0.000	0.000
9	89.550	0.430	1.055	0.178	456.389	59.459
10	100.650	1.406	2.320	0.147	219.082	28.620
11	59.142	1.581	1.586	0.145	48.758	8.361
12	80.866	0.929	0.801	0.041	39.4	6.957
13	163.680	1.270	4.631	0.417		5.144
14						
15						

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAXMIN	LAPLACE	MAXIMAX
1	12.5	10	10
2	4.5	5.5	7
3	3	3.5	3.5
4	8.5	11.5	13
5	12.5	13	11
6	18.5	8.5	8.5
7	6	14	5.5
8	15	7	14.5
9	11	3.5	5.5
10	14.5	9	3.5
11	8	15	8.5
12	10	11.5	15.5
13	14	12	11.5
14	10		
15	2		

RUN NUMBER: COST LOW-SAVINGS HIGH

DEVIATION LEVELS: 1 0.2 3 16
 COST : 1.256 1 0.33 16
 SAVINGS : 2 1 0.9
 HANPOWER : 1.1 1 0.33 16
 CASHFLOWS: 1.5 1 0.33 16

NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MAXROI	133.9	208	70.4	854	77.4	569	14.7	694	82.2	507	16.9	556	34.8	553	96.8
HINROI	11.7	34	1.9	29	6.8	13	1.8	11	7.2	27	4.6	63	1.4	24	1
MAXIRR	9.7	54	1.3	56	5.0	41	1.8	36	1.0	23	1.5	38	1.0	55	2
HINIRR	2.3	50	0.2	47	1.0	26	0.0	15	0.0	36	0.0	22	0.0	73	4
MAXHPS	34.5	85	107.9	310	32.0	360	11.0	340	0.0	000	0.0	000	0.0	577	0
HINHPS	11.2	67	15.5	169	3.0	405	0.0	400	0.0	000	0.0	000	0.0	452	0
MAXHPS	34.5	85	107.9	310	32.0	360	11.0	340	0.0	000	0.0	000	0.0	577	0
HINHPS	11.2	67	15.5	169	3.0	405	0.0	400	0.0	000	0.0	000	0.0	452	0

THE FINAL RANKINGS LISTED BY METHOD:

NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MAXIMIN	12	15	3.5	7.5	13.5	17.5	14	10.5	10.5	13.5	15.5	15.5	15.5	15.5	15.5
LAPLACE	10	7	3.5	13.5	11.5	8.5	14	6.5	9.5	15	11.5	11.5	11.5	11.5	11.5
MAXIMAX	1	10	3.5	13.5	11.5	8.5	14	6.5	9.5	15	11.5	11.5	11.5	11.5	11.5

RUN NUMBER: SAVINGS LOW - MANPOWER LOW

DEVIATION LEVELS: 1 0.825
 COST : 1.256 1 0.1
 SAVINGS : 1.014 1 0.2
 MANPOWER : 1.1 1 0.2
 CASHFLOWS: 1.014 1 0.1

NO	MAXROI	MINROI	MAXIRR	MINIRR	MAXHPS	MINHPS
1	54.683	31.848	71.4	5.998	20.716	2.503
2	28.846	15.237	59.3	0.543	29.437	3.545
3	28.718	16.491	70.3	3.302	5.900	2.376
4	31.962	18.477	56.8	0.582	0.000	0.000
5	31.488	13.332	1.027	0.000	0.000	0.000
6	19.768	19.522	1.747	0.587	0.000	0.000
7	16.735	11.386	0.555	0.626	0.000	0.000
8	21.400	12.657	1.320	0.529	0.000	0.000
9	14.338	18.358	0.394	1.762	0.259	0.360
10	19.604	23.429	0.801	0.520	0.000	0.000
11	39.680	11.134	4.631	0.711	0.000	0.000
12				4.110	0.000	0.000
13					0.000	0.000
14					0.000	0.000
15					0.000	0.000

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAX	MIN	LAPLACE	MAX	MIN	MAX
1	10	10	10	10	10	10
2	7	7	7	7	7	7
3	3	3	3	3	3	3
4	5	5	5	5	5	5
5	13	13	13	13	13	13
6	11	11	11	11	11	11
7	8	8	8	8	8	8
8	5	5	5	5	5	5
9	14	14	14	14	14	14
10	15	15	15	15	15	15
11	3	3	3	3	3	3
12	8	8	8	8	8	8
13	15	15	15	15	15	15
14	11	11	11	11	11	11
15	12	12	12	12	12	12

RUN NUMBER: COST, MANPOWER HIGH - SAVINGS LOW

DEVIATION LEVELS:	1 0.825
COST	: 2.514
SAVINGS	: 1.014
HANPOWER	: 2.2014
CASHFLOWS:	1 0.14

[illegible]

THE FINAL RANKINGS LISTED BY METHOD:

NO	HAXIMIN	LAPLACE	HAXIMAX
1	12.5	10.5	10.7
2	14.5	5.5	3.5
3	3.5	5.5	13.5
4	3.5	5.5	5.5
5	3.5	5.5	5.5
6	12.5	5.5	5.5
7	6.5	5.5	5.5
8	15.5	3.5	14.5
9	11.5	3.5	5.5
10	14.5	3.5	13.5
11	8.5	9.5	5.5
12	10.5	11.5	15.5
13	10.5	2.5	11.5
14	10.5	2.5	11.5
15	10.5	2.5	11.5

RUN NUMBER: COST HIGH-SAVINGS LOW

DEVIATION LEVELS: 1 0.825
 COSTS: 2.512
 SAVINGS: 1.014
 MANPOWER: 1.1
 CASHFLOWS: 1.014 1 0.1

NO	MAXROI	MINROI	MAXIRR	MINIRR	MAXMPS	MINMPS
1	54.683	2.963	6.714	0.749	29.716	9.432
2	28.709	1.487	3.913	0.066	35.437	8.372
3	31.569	1.530	3.593	0.073	19.900	0.505
4	31.710	1.723	3.568	0.081	10.800	0.200
5	31.952	1.767	3.568	0.081	10.800	0.200
6	31.952	1.767	3.568	0.081	10.800	0.200
7	31.952	1.767	3.568	0.081	10.800	0.200
8	31.952	1.767	3.568	0.081	10.800	0.200
9	31.952	1.767	3.568	0.081	10.800	0.200
10	31.952	1.767	3.568	0.081	10.800	0.200
11	31.952	1.767	3.568	0.081	10.800	0.200
12	31.952	1.767	3.568	0.081	10.800	0.200
13	31.952	1.767	3.568	0.081	10.800	0.200
14	31.952	1.767	3.568	0.081	10.800	0.200
15	31.952	1.767	3.568	0.081	10.800	0.200

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAXIMIN	LAPLACE	MAXIMAX
1	12.5	10.5	10.7
2	14.5	13.5	13.5
3	12.5	11.5	11.5
4	12.5	13.5	13.5
5	12.5	13.5	13.5
6	12.5	13.5	13.5
7	12.5	13.5	13.5
8	12.5	13.5	13.5
9	12.5	13.5	13.5
10	12.5	13.5	13.5
11	12.5	13.5	13.5
12	12.5	13.5	13.5
13	12.5	13.5	13.5
14	12.5	13.5	13.5
15	12.5	13.5	13.5

RUN NUMBER: COST HIGH - SAVINGS, NPS LOW

DEVIATION LEVELS: 1 0.825
 COST : 2.512
 SAVINGS : 1.014
 HANPOWER : 1.1
 CASHFLOWS: 1.014 1 0.1

NO	MAXROI	MINROI	MAXIRR	MINIRR	MAXNPS	MINNPS
1	54.6227	1.769	6.714	0.066	20.961	1.252
2	28.8469	0.290	0.913	0.073	29.716	1.774
3	38.718	0.913	0.933	0.073	19.437	1.908
4	31.962	0.023	0.703	0.080	0.900	1.188
5	31.488	0.193	0.686	0.085	0.840	1.001
6	33.765	0.018	1.028	0.115	0.000	0.000
7	16.700	0.097	1.107	0.099	0.000	0.000
8	21.438	0.640	0.747	0.049	0.000	0.000
9	24.400	0.790	1.050	0.178	0.250	0.007
10	19.338	0.464	0.324	0.147	0.000	0.180
11	39.680	0.634	0.580	0.015	0.037	0.000
12		1.285	4.631	0.047	16.571	0.707
13						0.952
14						0.572
15						

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAX	MIN	LAPLACE	MAX	MIN	MAX
1	12.5	1	10	10	17	1
2	14.5	5	5.5	3	3	5
3	3	5	11.5	13	11	5
4	8	5	13	8	5	5
5	12.5	5	5	5	5	5
6	6	5	14	5	14	5
7	15	5	7	3	5	5
8	11	5	9	5	5	5
9	14.5	5	15	5	5	5
10	18	5	12	5	15	5
11	10	2	11	2	11	5
12						
13						
14						
15						

RUN NUMBER: SAVINGS HIGH (2)

DEVIATION LEVELS: 1 0.825
 COSTS : 1.256
 SAVINGS : 1.392
 HANPOWER : 1.1
 CASHFLOWS: 1.5

NO	HAXBOI	HIMBOI	HAXIER	HIMIER	HAXHPS	HIMHPS
1	65.553	13.232	7.985	2.647	20.961	11.265
2	10.781	2.176	1.098	0.301	25.716	15.291
3	34.615	6.937	0.613	1.423	5.430	35.165
4	33.851	7.832	0.723	0.232	19.900	10.045
5	38.157	1.648	0.834	0.197	0.800	30.000
6	37.143	7.618	1.239	0.379	0.000	0.000
7	40.723	8.687	1.328	0.406	0.000	0.000
8	23.956	4.780	0.280	0.287	0.000	0.000
9	27.922	1.601	1.792	0.283	0.259	0.000
10	26.080	5.310	2.393	0.832	10.200	52.420
11	29.225	3.478	0.961	0.219	0.837	0.361
12	17.323	4.748	0.701	0.234	0.667	0.000
13	23.616	9.611	5.557	1.706	16.571	85.353
14						5.143
15						

THE FINAL RANKINGS LISTED BY METHOD:

FROM	HAXBOI	HIMBOI	LAPLACE	HAXHPS	HIMHPS
1	1	10	1	10	1
2	5	5	3	3	5
3	5	3	13	13	5
4	5	11	11	11	5
5	5	18	5	5	5
6	5	14	5	5	5
7	5	3	5	5	5
8	5	15	5	5	5
9	5	9	5	5	5
10	5	12	5	5	5
11	5	15	5	5	5
12	5	12	5	5	5
13	5	12	5	5	5
14	5	12	5	5	5
15	5	12	5	5	5

RUN NUMBER: COST HIGH

DEVIATION LEVELS:
 COSTS: 1 0.99
 SAVINGS: 2 0.316
 MANPOWER: 1 0.9
 CASHFLOWS: 1 0.316

NO	MAXBOI	MINBOI	MAXIR	MINIR	MAXRPS	MINRPS
1	45.5266	9.188	7.14	2.228	17.4631	19.3387
2	24.0388	1.51	2.913	2.228	24.5331	3.3086
3	23.4531	4.45	2.933	2.228	16.5380	3.3086
4	23.4531	5.175	2.933	2.228	16.5380	3.3086
5	23.4531	5.175	2.933	2.228	16.5380	3.3086
6	23.4531	5.175	2.933	2.228	16.5380	3.3086
7	23.4531	5.175	2.933	2.228	16.5380	3.3086
8	23.4531	5.175	2.933	2.228	16.5380	3.3086
9	23.4531	5.175	2.933	2.228	16.5380	3.3086
10	23.4531	5.175	2.933	2.228	16.5380	3.3086
11	23.4531	5.175	2.933	2.228	16.5380	3.3086
12	23.4531	5.175	2.933	2.228	16.5380	3.3086
13	23.4531	5.175	2.933	2.228	16.5380	3.3086
14	23.4531	5.175	2.933	2.228	16.5380	3.3086
15	23.4531	5.175	2.933	2.228	16.5380	3.3086

THE FINAL RANKINGS LISTED BY METHOD:

PROJ	MAXIR	MINIR	LAPLACE	MAXIR	MAX
1	10.5	10.5	10.5	10.5	10.5
2	13.5	13.5	13.5	13.5	13.5
3	13.5	13.5	13.5	13.5	13.5
4	13.5	13.5	13.5	13.5	13.5
5	13.5	13.5	13.5	13.5	13.5
6	13.5	13.5	13.5	13.5	13.5
7	13.5	13.5	13.5	13.5	13.5
8	13.5	13.5	13.5	13.5	13.5
9	13.5	13.5	13.5	13.5	13.5
10	13.5	13.5	13.5	13.5	13.5
11	13.5	13.5	13.5	13.5	13.5
12	13.5	13.5	13.5	13.5	13.5
13	13.5	13.5	13.5	13.5	13.5
14	13.5	13.5	13.5	13.5	13.5
15	13.5	13.5	13.5	13.5	13.5

DEVIATION	:	1	0.0000
COSTINGS	:	1	0.0000
SAVINGS	:	1	0.0000
HANPOWER	:	1	0.0000
CASHFLOWS	:	1	0.0000
STRAT	:	1	0.0000

DEVIATION	:	1	0.0000
COSTINGS	:	1	0.0000
SAVINGS	:	1	0.0000
HANPOWER	:	1	0.0000
CASHFLOWS	:	1	0.0000
STRAT	:	1	0.0000

[illegible]

THE FINAL RANKINGS LISTED BY METHOD:
NO MAXIMIN LAPLACE MAXIMAX

[illegible]

RUN NUMBER: COST HIGH - HANDPOWER HIGH

DEVIATION LEVELS: 1 0.825
 COST : 2.512
 SAVINGS : 1.014
 HANDPOWER : 2.236
 CASHFLOWS: 1.014 1 0.3336

NO	MAXBOI	HINBOI	MAXIRR	HINIRR	MAXHPS	HINHPS
1	54.6287	9.8253	6.7714	2.3369	29.9671	9.9556
2	38.8469	5.6158	0.5933	0.2247	25.4300	1.1153
3	31.9164	5.073	0.7033	0.2677	19.9000	1.0820
4	31.9164	5.073	0.6868	0.257	19.9000	1.0820
5	31.9164	5.073	0.6868	0.257	19.9000	1.0820
6	31.9164	5.073	0.6868	0.257	19.9000	1.0820
7	31.9164	5.073	0.6868	0.257	19.9000	1.0820
8	31.9164	5.073	0.6868	0.257	19.9000	1.0820
9	31.9164	5.073	0.6868	0.257	19.9000	1.0820
10	31.9164	5.073	0.6868	0.257	19.9000	1.0820
11	31.9164	5.073	0.6868	0.257	19.9000	1.0820
12	31.9164	5.073	0.6868	0.257	19.9000	1.0820
13	31.9164	5.073	0.6868	0.257	19.9000	1.0820
14	31.9164	5.073	0.6868	0.257	19.9000	1.0820
15	31.9164	5.073	0.6868	0.257	19.9000	1.0820

THE FINAL RANKINGS LISTED BY METHOD:

NO MAXIN LAPLACE MAXIN

NO	MAXIN	LAPLACE	MAXIN
1	10	10	10
2	5	5	5
3	5	5	5
4	5	5	5
5	5	5	5
6	5	5	5
7	5	5	5
8	5	5	5
9	5	5	5
10	5	5	5
11	5	5	5
12	5	5	5
13	5	5	5
14	5	5	5
15	5	5	5

RUN NUMBER: UNCERTAINTY BASE

DEVIATION LEVELS: 1 0.925
 COSTS: 1 0.316
 SAVINGS: 1 0.014
 HANPOWER: 1 0.9316
 CLSHPLOWS: 1 0.3116

NO	HAXROI	HAXIHI	HAXIHR	HAXIIR	HAXHPS	HINHPS
1	54.627	11.082	6.714	20.237	20.716	11.265
2	28.809	11.822	0.513	22.34	29.437	15.970
3	31.718	5.624	0.303	1.234	19.900	10.000
4	31.954	2.600	0.686	1.154	0.840	3.000
5	33.480	2.343	0.010	3.408	0.000	0.000
6	16.735	3.380	1.107	1.339	0.000	0.000
7	16.700	3.382	0.155	2.397	0.000	0.000
8	21.438	4.382	2.320	0.608	0.409	0.000
9	19.304	2.857	0.386	1.173	0.200	0.000
10	39.680	8.009	4.801	0.243	15.250	58.000
11			4.631	0.000	16.967	0.000
12				1.420	19.571	0.000
13				1.242	0.365	0.000
14				1.420	0.000	0.000
15				1.420	0.000	0.000

THE FINAL RANKINGS LISTED BY METHOD:

NO	HAXIHI	LAPLACE	HAXIHR	HAXIIR
1	10.5	10.5	10.5	10.5
2	13.5	13.5	13.5	13.5
3	13.5	13.5	13.5	13.5
4	13.5	13.5	13.5	13.5
5	13.5	13.5	13.5	13.5
6	13.5	13.5	13.5	13.5
7	13.5	13.5	13.5	13.5
8	13.5	13.5	13.5	13.5
9	13.5	13.5	13.5	13.5
10	13.5	13.5	13.5	13.5
11	13.5	13.5	13.5	13.5
12	13.5	13.5	13.5	13.5
13	13.5	13.5	13.5	13.5
14	13.5	13.5	13.5	13.5
15	13.5	13.5	13.5	13.5

DEVIATION	1	0.9256
COST	1	0.3316
SAVINGS	1	0.3316
HANDPICKS	1	0.3316
CYCLESTIME	1	0.3316

[illegible]

THE FINAL RANKINGS LISTED BY METHOD:

HAXININ	LAPLACE	HAXIMAX
10	10	10
1	3	3
2	13	13
3	1	1
4	18	18
5	14	14
6	3	3
7	14	14
8	1	1
9	10	10
10	3	3
11	10	10
12	1	1
13	5	5
14	5	5

RUN NUMBER: SAVINGS LOW

DEVIATION LEVELS: 1 0.825
 COST : 1.256
 SAVINGS : 1.014
 HANDOVER : 1.1
 CASHFLOWS: 1.014

NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MAXROI	54.627	28.983	28.709	31.718	31.964	33.480	33.768	36.700	24.400	24.338	19.604	39.680			
MINROI	31.848	15.237	16.491	13.477	13.352	11.528	13.867	14.358	8.229	11.429	23.134				
MAXIRR	6.714	0.913	0.593	0.635	0.686	1.027	1.107	1.745	2.320	1.994	0.801	4.631			
MINIRR	5.998	0.807	0.543	0.582	0.643	0.913	0.987	1.659	2.059	1.520	0.711	4.110			
MAXHPS	20.961	29.716	25.437	19.900	67.840	0.000	0.000	0.000	103.250	11.837	16.571				
MINHPS	11.265	15.167	35.195	10.600	36.400	0.000	0.000	0.000	58.622	6.361	8.514				

THE FINAL RANKINGS LISTED BY METHOD:

NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MAXIN LAPLACE	10	7	3	5	13	11	8	5	5	5	5	5	5	5	5
MAXIN	10	7	3	5	13	11	8	5	5	5	5	5	5	5	5

RUN NUMBER: COST LOW (2)

DEVIATION LEVELS: 1 0.66
 COSTS : 1.0048 1 0.3116
 SAVINGS : 1.014 1 0.9116
 MANPOWER : 1.1 1 0.3116
 CASH FLOWS : 1.014 1 0.3116

NO	MAXROI	MINROI	MAXIRR	MINIRR	MAXMPS	MINMPS
1	68.284	13.783	6.714	2.237	26.201	14.081
2	11.230	2.266	0.913	2.234	37.145	19.955
3	36.262	7.718	3.703	1.234	31.797	43.360
4	39.267	8.102	0.686	1.254	24.876	10.573
5	39.455	1.045	1.028	1.386	0.800	45.000
6	39.350	7.548	1.107	1.360	0.800	0.000
7	42.710	8.587	1.747	1.340	0.800	0.000
8	24.294	4.674	1.055	1.399	0.800	0.000
9	8.137	1.677	2.320	1.687	136.574	74.328
10	30.500	5.156	1.994	0.608	38.000	0.001
11	17.922	3.617	0.586	1.173	0.796	7.051
12	24.505	4.946	0.801	1.420	20.833	11.196
13	49.600	10.012	4.631	1.420	11.964	16.429

THE FINAL RANKINGS LISTED BY METHOD:

PROJ	MAXMIN	LAPLACE	MAX	MIN	MAX
1	12	10	10	10	10
2	5	6.5	7	7	7
3	3.5	3.5	3	3	3
4	7.5	11.5	13	13	13
5	5.5	13.5	11	11	11
6	5.5	13.5	11	11	11
7	5.5	13.5	11	11	11
8	5.5	13.5	11	11	11
9	5.5	13.5	11	11	11
10	5.5	13.5	11	11	11
11	5.5	13.5	11	11	11
12	5.5	13.5	11	11	11
13	5.5	13.5	11	11	11
14	5.5	13.5	11	11	11
15	5.5	13.5	11	11	11

RUN NUMBER: SAVINGS HIGH - MPS HIGH

DEVIATION LEVELS:
 COSTS: 1 0.825
 SAVINGS: 1 0.3316
 HANPOWER: 1 0.9
 CASHFLOWS: 1 0.3316

NO	MAXROI	HINROI	MAXIRR	HINIRR	HAXHPS	HINHPS
1	107.750	11.7348	12.869	2.369	38.110	11.265
2	17.720	1.9298	1.809	0.250	54.980	11.970
3	16.840	1.9565	0.953	0.247	18.183	15.165
4	55.559	6.8130	1.013	0.267	36.000	10.000
5	61.764	6.2812	1.372	0.153	123.000	36.000
6	11.036	1.7575	1.024	0.362	0.000	0.000
7	66.908	6.2252	2.184	0.362	0.000	0.000
8	33.988	4.4652	1.432	0.234	0.000	0.000
9	33.089	4.5322	2.139	0.234	0.163	0.000
10	32.019	4.5322	3.632	0.234	296.000	58.000
11	28.267	3.2071	1.158	0.648	0.000	0.000
12	38.265	4.2110	1.580	0.186	21.520	0.361
13		8.5223	9.133	0.251	30.302	8.5
14						
15						

THE FINAL RANKINGS LISTED BY METHOD:

NO	HAXINH	LAFACE	HAXINH
1	10	10	10
2	3	3	3
3	5	5	5
4	13	13	13
5	11	11	11
6	18	18	18
7	14	14	14
8	5	5	5
9	15	15	15
10	3	3	3
11	14	14	14
12	11	11	11
13	12	12	12
14	10	10	10
15	15	15	15

RUN NUMBER: COST HIGH - SAVINGS HIGH

DEVIATION LEVELS:
COST : 2.512
SAVINGS : 1 0.825
HANDPOWER : 1 0.3316
CASHFLOWS : 2 1 0.9316

NO	MAXROI	MINROI	MAXTIER	MINTIER	MAXEPS	MINEPS	S
1	107.7500	5.8671	12.8093	2.3250	20.961	5.984	22
2	17.7296	0.9648	1.0953	0.2247	2.716	17.584	34
3	56.6494	0.9981	0.1823	0.2677	5.900	5.302	47
4	62.5736	0.0655	1.0172	0.1577	0.000	0.000	99
5	11.0829	0.3787	1.3027	0.1362	0.000	0.000	00
6	66.9989	0.3383	1.1842	0.3654	0.000	0.000	00
7	38.0812	0.1226	2.1519	0.3248	0.000	0.000	09
8	48.0812	0.3166	2.4315	0.7348	0.000	0.000	11
9	28.2665	0.3209	1.9158	0.6186	0.259	0.310	00
10	78.2665	0.5355	3.1580	0.8602	13.020	14.031	00
11		0.2617	1.9158	0.8602	0.837	0.189	00
12		2.4261	1.9158	0.8602	16.571	3.425	11
13							
14							
15							

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAXMIN	LAPLACE	MAXIMAX
1	12	10	10
2	3	7	7
3	5.5	3.5	3.5
4	13	13	13
5	7.5	11	11
6	17.5	8.5	8.5
7	6	14	14
8	14.5	5.5	5.5
9	10.5	5.5	5.5
10	9	5.5	5.5
11	15	14.5	14.5
12	10.5	11.2	11.2
13			
14			
15			

RUN NUMBER: HANPOWER LOW

DEVIATION LEVELS: 1 0.825
 COST : 1.256
 SAVINGS : 1.014
 HANPOWER : 1.1
 CASH FLOWS: 1.014

NO	MAXROI	HANROI	MAXIRR	HANIRR	MINIRR	MAXEPS	HANEPS	MINEPS
1	54.682	11.739	71.3	60.0	20.0	29.7	9.7	1.2
2	8.846	1.969	10.3	0.3	0.0	0.7	0.7	0.0
3	28.271	6.130	30.3	0.3	0.0	1.6	1.6	0.0
4	31.565	8.130	32.6	0.0	0.0	0.7	0.7	0.0
5	33.765	10.160	32.7	0.0	0.0	0.7	0.7	0.0
6	33.765	11.771	32.7	0.0	0.0	0.7	0.7	0.0
7	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
8	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
9	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
10	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
11	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
12	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
13	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
14	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0
15	33.765	12.232	32.7	0.0	0.0	0.7	0.7	0.0

THE FINAL RANKINGS LISTED BY METHOD:

NO	MAXMIN	LAFACE	MAXIMAX
1	1	10	10
2	2	6	7
3	3	3	3
4	4	3	3
5	5	3	3
6	6	3	3
7	7	3	3
8	8	3	3
9	9	3	3
10	10	3	3
11	11	3	3
12	12	3	3
13	13	3	3
14	14	3	3
15	15	3	3

RUN NUMBER: COST LOW - SAVINGS, NPS HIGH

DEVIATION LEVELS:
 COST : 1.256
 SAVINGS : 2.2
 HANPOWER : 2.2
 CASHFLOW: 2.2

NO	HAXROI	HINROI	HAXIRI	HINIRI	HAXHPS	HINHPS
1	44.450	11.734	1.869	2.350	157.281	11.391
2	73.090	1.922	1.809	0.257	22.78	39.165
3	69.0	1.969	0.532	2.267	99.25	16.099
4	51.09	1.313	1.152	0.000	0.000	0.000
5	50.2	1.020	1.372	1.536	0.000	0.000
6	27.5	1.757	1.022	3.362	0.000	0.000
7	50.0	1.242	1.824	3.234	0.000	0.000
8	53.0	1.222	1.139	2.484	0.000	0.000
9	98.0	1.464	1.632	2.348	0.000	0.000
10	63.0	1.241	1.158	1.648	29.0	52.620
11	52.0	1.011	1.932	2.186	88.0	0.361
12	50.0	1.223	1.583	1.360	125.78	39.165
13	159.840	4.823	9.133	0.131	171.0	8.514

THE FINAL RANKINGS LISTED BY METHOD:

NO	HAXIRI	LAFLACE	HAXINAX
1	10	10	10
2	3	3	3
3	7.5	7.5	7.5
4	13	13	13
5	11	11	11
6	8	8	8
7	14	14	14
8	5	5	5
9	15	15	15
10	9	9	9
11	12	12	12
12	6	6	6
13	1	1	1
14	4	4	4
15	2	2	2

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